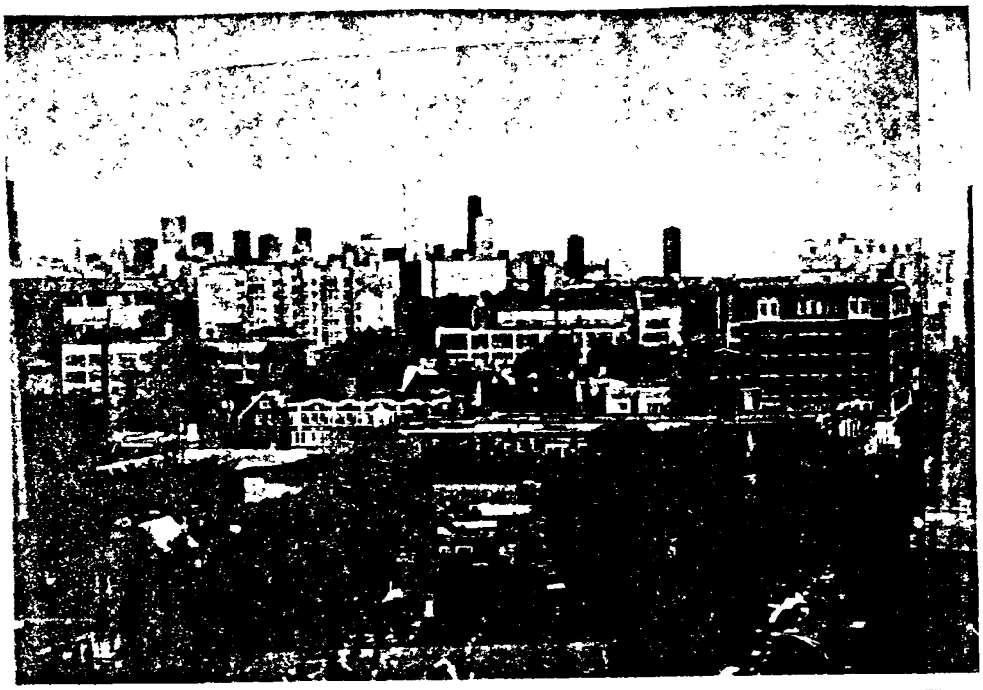

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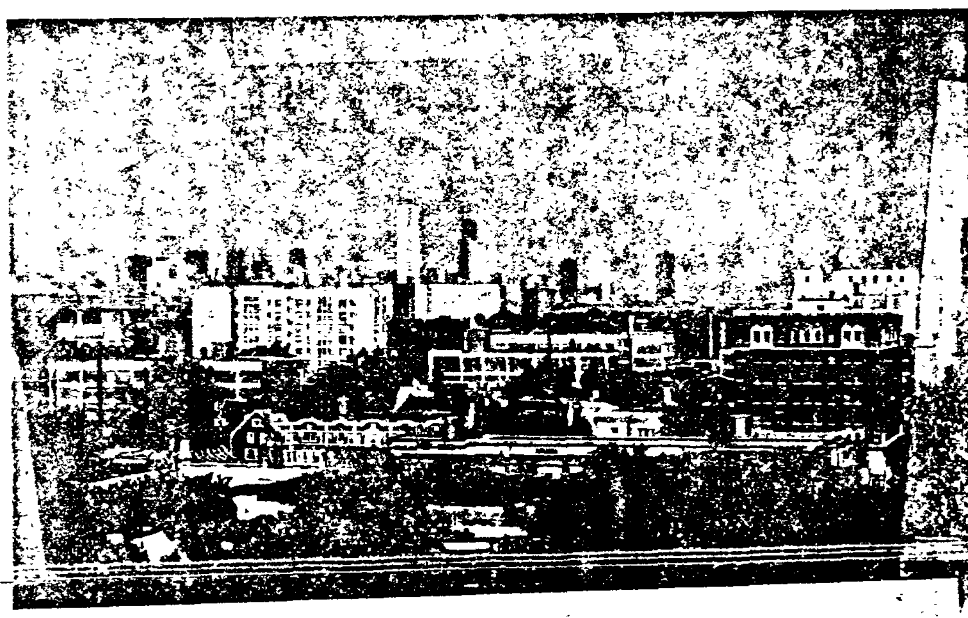

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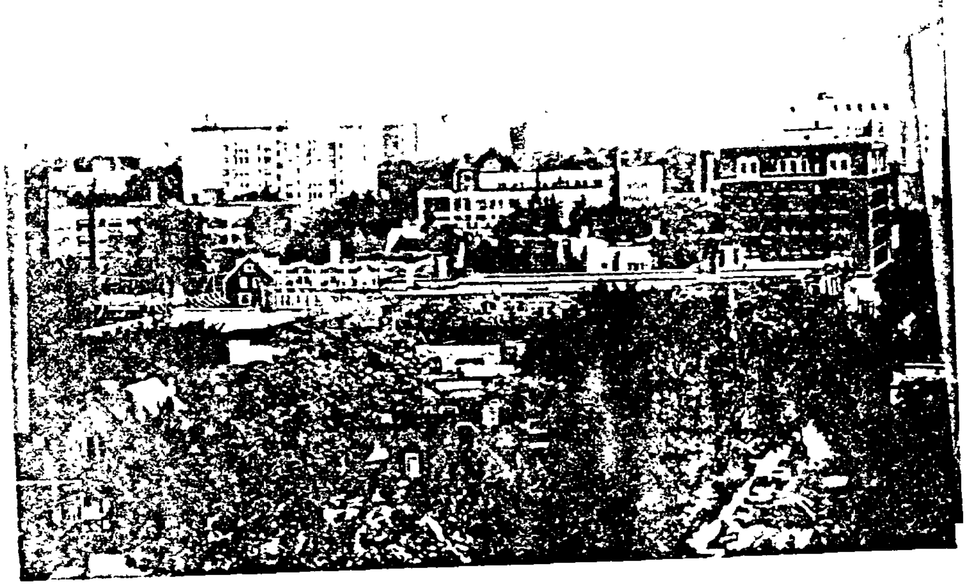

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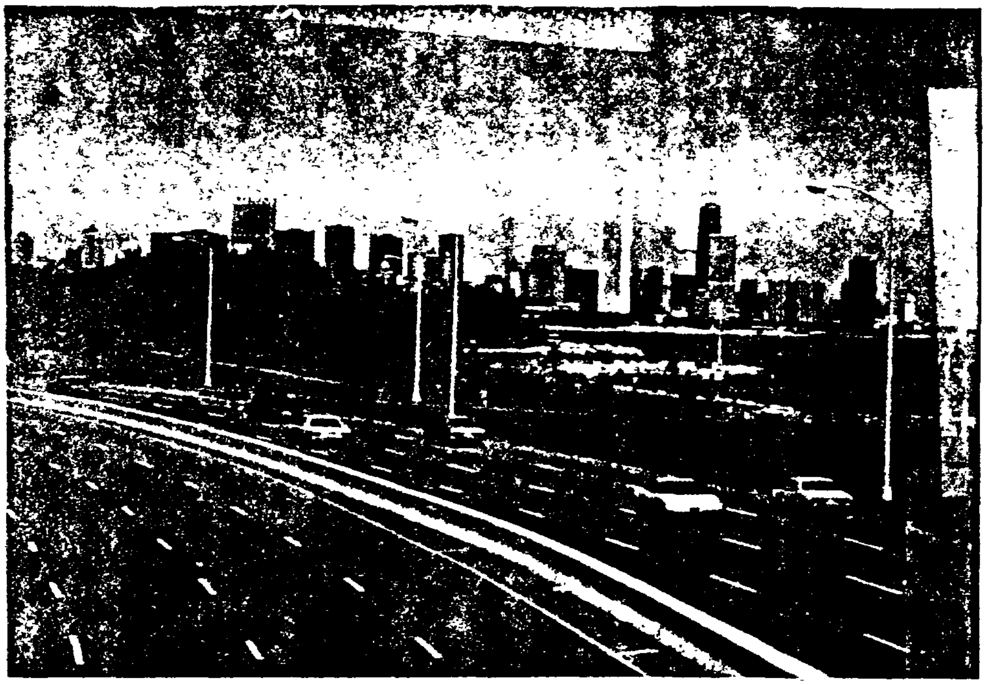

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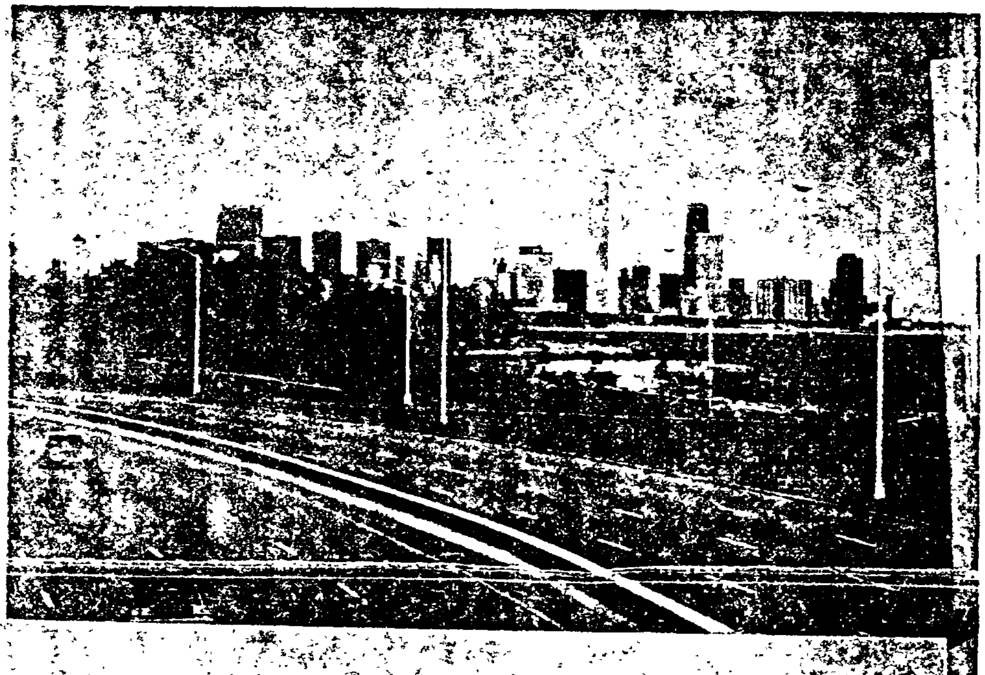
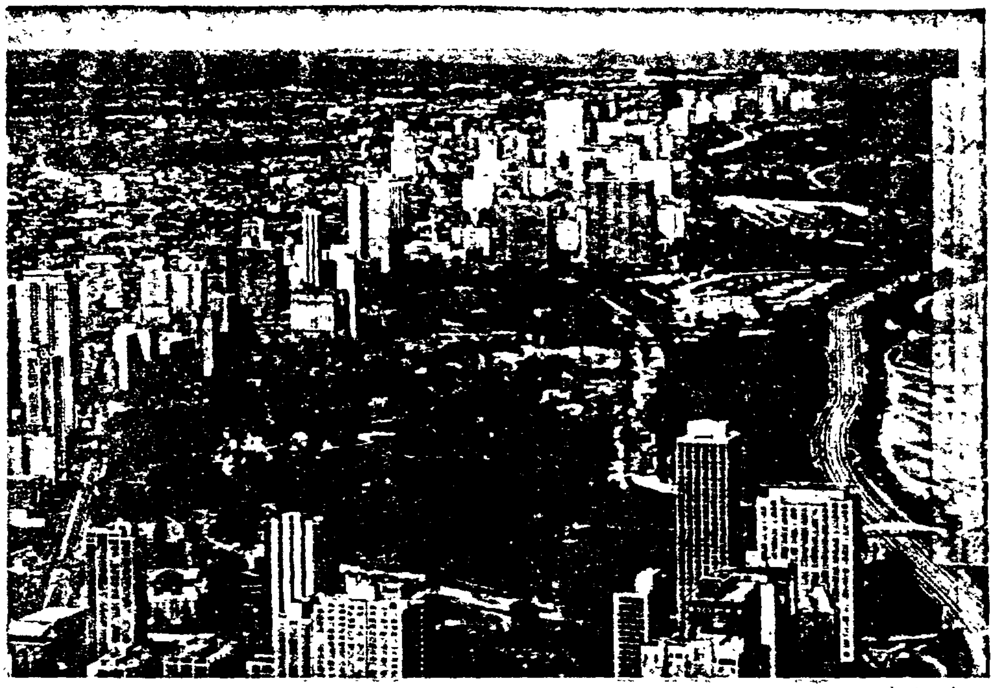


L-II-2

L-II-1



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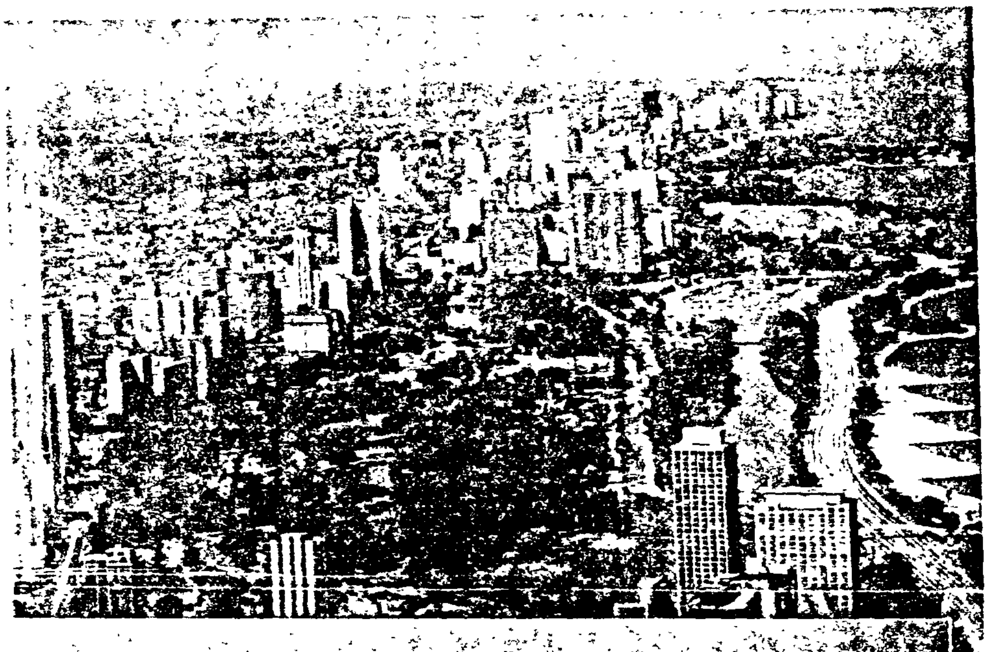
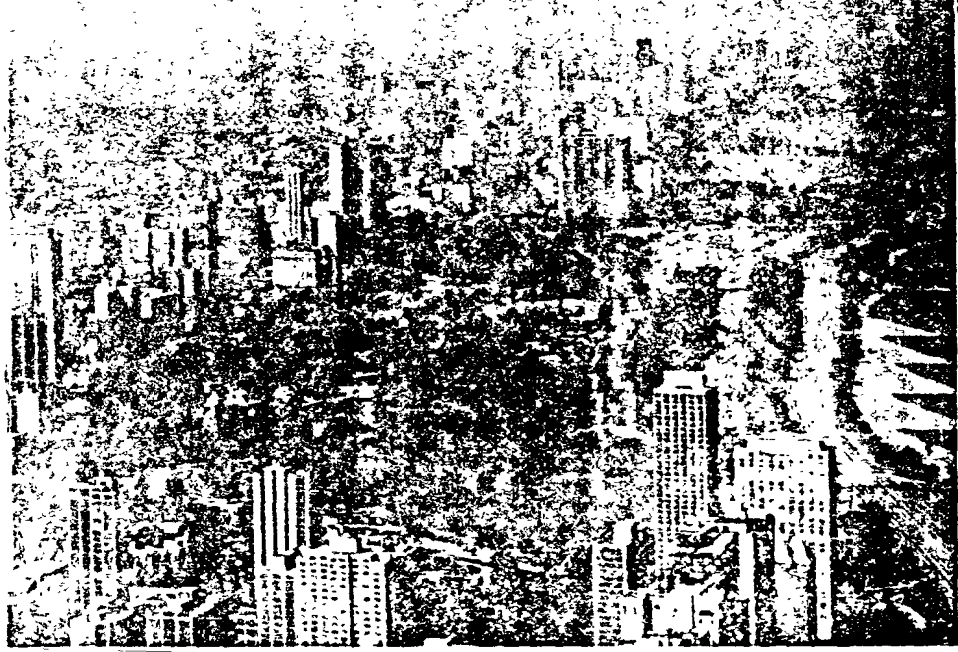


L-III-✓



L-III-1

1. [Hand respondent Activity Sheet]
Please look at this sheet. It lists some of the things people do with their time. Place an X beside each activity that you do in the course of an ordinary year. If there are any other activities that you do, check the spaces marked 'other'.

[Pause, for respondent to complete Activity Sheet]

2. Do you own or have the use of the following items?
[Check For Yes]

_____ Binoculars

_____ A light plane, glider, hang glider, or hot air balloon

_____ A birdwatcher's guide

_____ A recreation vehicle, camper, or motor home

_____ A guidebook for amateur astronomers

_____ A camera with telephoto lens

_____ Backpacking equipment

_____ A vacation home or cabin

[Present photograph set]

3. Now, please look at these photographs. Each row shows the same scene, only with different visibility. [point to photos] The pictures on the left show a visibility of 4 miles. The ones in the center show 13 miles, and the ones on the right show 30 miles, Notice that when visibility increases you can see farther, and the things you <u>do</u> see become sharper and more distinct. [PAUSE]

a) [Present card A] This card shows the relationship between the photos and visibility. If you had to guess how many miles would you think you could see on a typical Atlanta day? It doesn't have to be one of these photos, they are just there to help you.

<u>Enter Guess</u> (In Miles) ______

Records show that typical visibility in the Atlanta area is actually about 10 miles.

Please look again at the activity sheet.

b) Are there any activities which you <u>would</u> do on a day with 30 miles visibility, which you <u>wouldn't</u> do with 13 miles? Which ones?

---

c) Are there any activities which you <u>would</u> do on a day with 13 miles which you <u>wouldn't</u> do with 4 miles? Which ones?

In the following questions, we would like you to answer for your entire household, that is, any one who contributes to, or is supported by, household income. To understand your answers, we need to know how many people are in your household. How many are there?

Enter # in household ___________

4. Let us return to the photographs.

Visibility is affected by both natural and man-made causes. In particular, there are a number of man-made things in the air which do not affect health but do affect visibility. We can do something to affect these things, but this costs all of us money, since it makes the things we buy more expensive. The following questions are designed to help us find out how much visibility is worth to you.

[Present Expenditure Card, and then read slowly]

I'd like you to look at this card. It shows how much a typical household with the indicated income spends each month for various things. Included are expenses for ordinary goods, like groceries and housing. Also, it shows how much is paid, through taxes and higher prices, for various public programs. Some of these expenses are quite small, like for toothpaste and the space program, while others are quite large, like for housing and national defense.

[Pause, to allow respondent to examine card.]

You may look at this card if you wish to help answer the next few questions.

[Present Card B]

4a.. Typical visibility in the Atlanta area is 10 miles. Consider what would happen if typical visibility in Atlanta fell to 5 miles. A program could be set up to prevent the decline. If the total cost of the program to you/[your household] was $13 a month, would you accept the program or reject it?

Accept_____

[Check One]

Reject_____

Now, assume the program would cost $___*___/month. Would you accept the program or reject it?

* [Follow Bidding Instructions. If respondent bids zero, ask QUESTION 4b. Otherwise, enter BID4 and go on to question 5)

[Enter maximum amount ACCEPTED.]

$__________/month [BID4]

****

4b. ONLY THOSE WHOSE FINAL RESPONSE WAS $ZERO FOR QUESTION 4a. [Present Card C]

Did you reject the program which would spend your money to maintain visibility because:
[Check Only One]

_____ Visibility is not worth anything to you (or, it wouldn't matter even if visibility declined to 5 miles).

__*__ You would appreciate [or value] improved visibility, but you think someone else should be made to pay for it.

__*__ Some other reason: ______________________

____

* [If respondent says someone else should pay, then say:]

Later, you will get a chance to say who should pay. For now, we are interested in finding out how much it is worth to you. Let's say that you <u>could</u> buy visibility, and there was no one else to pay or enjoy the benefits. Then, would you be willing to Pay something?

YES_____ (Go back to 4a.) NO_____ [Go on to Q 5.]

[Present Card D]

5. Now let's go back to the our starting point, where typical visibility is 10 miles. A program could be set up to improve it to 20 miles. Suppose the <u>total</u> cost of the program to you would be $13 a month. Would you accept the program, or reject it? (Point out change on Card D)

Accept______

Reject______

[Check One]

What if it cost $_____*_____/month. Would you accept the program or reject it and stay at 10 miles?

*(Bidding as for Q.4)

$____________/month [BID5: Remember this amount]

Present Card E]

For the next question:

If BID5 is GREATER THAN ZERO, say the words in (). If BID5 was ZERO, say the words in < >.

6. Now, what if the program improved visibility all the way to 30 miles?

Would you accept the 32 mile program if it cost

($10 more, for a total of $ [BID5 + 10] per month?)

[OR]

<$13 a month?>

Accept ______

Reject ______

[Check One]

What if it cost $____*____/month (more, for a total of $ (BID5 + *1 ?) Would you accept the program or reject it?

*(Bidding as for Q.4)

Enter both BID5, the additional amount bid for Q.6, and BID6, in the three answer blanks provided.

ENTER: $________ + $________ MORE = $__________/month
(BID5) (BID6)

[Present Card F and Eastern U.S. Photo Set]

7. Now let's consider a program which would improve visibility in Atlanta by ten miles, AND ALSO improve visibility in the rest of the Eastern section of the United States by ten miles. The shaded area on this map shows the area to be covered by this program. [BE SURE RESPONDENT UNDERSTANDS THAT THE ATLANTA AREA IS INCLUDED!]

(Before, you accepted a ten mile improvement in Atlanta alone when it cost $[BID5]/month.)

If this program cost you/your household

($10 a month more, for a total of $ [BID5 + 10])

<$13 a month>

would you accept the program or reject it?

Accept ______

Reject ______

[Check One]

What if it cost $____*____/month (more, for a total of $ [BID5 + *] ?) Would you accept the program or reject it?

*[Bidding as for Q.6]

FILL IN ALL BLANKS:

ENTER: $________ (BID5) + $________ MORE = $__________ (BID7) /month

[Present Card G]

8. One last program. [Show WEST picture set] This row of photos shows a scene from the western United States.

Now, consider a program which would improve typical visibility by ten miles over the entire country, [Show Map] Visibility in Atlanta would go to 20 miles, and all other places in the country would get similar improvements. If the program cost your household

(an additional $10, for a total of $ (BID7 + 10))

[OR]

<$13 a month>

would you accept the program or reject it?

Accept ______

Reject ______

[Check One]

What if it cost $ ___*___ /month (more, for a total of $ [BID7 + *] ?) Would you accept the program or reject it?

*[Bidding as for Q.6]

FILL IN ALL BLANKS:

ENTER: $ ________ + $ ________ MORE = $ ________ /month

(BID7) (BID8)

10a. Who should pay the costs of pollution control? [You may check more than one]

Ordinary Citizens	______
The Polluters	______
The Government	______

[Present Card H]

10b. For some years now, government and industry have been spending money to control pollution and improve the environment. Which of the following three statements best expresses your views about this?

[Check One]

Current levels of spending will eventually balance environmental quality and economic goals.	______
It is time to cut back on spending for environmental purposes.	______
We need to spend more, to achieve the kind of environment we want.	______

Now, a few more questions.

11. Do you own or rent the residence you live in? [Check One]

______Own (go to 12a)
______Rent (go to 12c)
______Other (go to 12d)

12a. OWN: If, for some reason, you wanted to rent out your residence, how much rent would you expect to receive? (or: what would a residence like this bring on the rental market?)

$__________/month

b.[IF DOES NOT KNOW] Perhaps it might be easier to think about the sale price. If you needed to sell your residence within 2 months and the buyer would have to arrange his/her own financing, how much do you think it would sell for?

$__________(sale price)

c.RENT: How much do you pay per month to rent this (house,apartment)?

$__________/month

d.OTHER: If you had to rent a house or an apartment like this on the rental market, how much do you think you'd have to pay?

$__________/month

13a Do you have any definite plans to move your residence in the next five years?

Yes _____
No _____

b [If a:Yes] when you move, do you expect to settle west of the Mississippi River?

Yes_____ No_____ Don't know_____

c. Do you expect to retire somewhere near Atlanta?

Yes _____ No_____ (go to d)
Currently retired _____ Don't know_____

d. [If c:No] Then, do you expect to retire:
(Check One)

Somewhere east of the Mississippi River_____
Somewhere west of the Mississippi River_____
Other_____

14a Do you own any residential property(houses, apartments), other than the place you are living in?

No_____
Yes____ [Continue]

b. Is this property located:

In or near Atlanta _____
Elsewhere in the eastern U.S. _____
Other _____

(Check All That Apply)

c. How much do you receive in monthly rents from residential property:

In or near Atlanta? $__________/month
Elsewhere in the eastern U.S.? $__________/month

15. [Show Card I] Please choose the best description of the view you have from your residence, and give me the number.

Number from card. _______

SOCIODEMOGRAPHIC DATA

So that we can analyze the responses we get from different people, we need to ask you a few questions about your household. Your answers will be completely confidential.

16. Of the people who usually live in your household, how many are children, 18 years or younger?

____

17a. For those who are not children, please fill in the table.
[The following notes are for the interviewer's guidance]

#: Each person is assigned a #, 1,2,3, etc.. The head of the household is always #1. Circle the # which represents the Respondent.
Relationship to Head: Indicate the customary family relationships (spouse, son, grandmother, etc.). For non-family relationships, just write "friend".

Education: What is the highest grade or year in school completed?

NONE....................0
ELEMENTARY.............1 2 3 4 5 6 7 8
HIGH SCHOOL............9 10 11 12
COLLEGE................13 14 15 16
SOME GRADUATE SCHOOL...17 18
GRADUATE OR
PROFESSIONAL DEGREE....20

SCHOOL: Is ...currently attending a School, College or University FULL TIME?
WORK: Does ...usually work [or seek employment] outside the household?
IF NO, go to next person.
IF YES, continue.
MONTHS: How many months did ...work in 1981?
HOURS: How many hours/week did ...usually work in 1981?
WAGE: [record either HOURLY, WEEKLY, OR MONTHLY WAGE]

17b. Do you have any of the following?
[Check those that apply]

_____Poor eyesight
_____Allergies (e.g., hay fever, asthma)
_____Any chronic respiratory ailment [e.g. T.B., emphysema, etc.)

PERSON	1. HEAD OF HOUSE-HOLD	2.	3.	4.	5.	6.	7.
AGE							
RELATION TO HEAD	X X X X X X X X X						
SEX (M/F)							
EDUCATION							
IN SCHOOL (YES/NO)							
WORK 1981 (YES/NO)							
MONTHS WORKED 1981							
HOURS WORKED PER WEEK 1981							
HOURLY WAGE [OR]							
WEEKLY WAGE [OR]							
MONTHLY WAGE							

18. [Race/ethnic group, of respondent. Interviewer Check One].

Asian________
Black________
Hispanic____
White________
Other________

19. In your household, do you: [Check One]

a. _____ share or pool your incomes, as a family or couple might do.
b. _____ live alone, or keep your personal incomes separate, as friends sharing a house/apartment might do.

20. [Present Card J] Please look at this card. Tell me which letter best describes your [household if 19a; or personal if 19b] income before taxes in 1981. Include income from all sources, including work, investments, business profits, interest on savings, pensions social security, support from relatives, and any other benefits.

_____ [Letter]
_____ [Refused, or didn't know and refused to guess].

21. Was your personal income in 1981 [Check One]

about the same as other recent years? _____

much higher than in other recent years? _____

much lower than in other recent years? _____

22. Would you expect your income, corrected for inflation [Or your purchasing power, Or your standard of living] in five years' time to be:

about the same as in 1981? _____

much higher than in 1981? _____

much lower than in 1981? _____

23. [Does your household if 19a; Do you if 19b]
[Check One]

manage to save or invest a little? _____

just get by on current income? _____

have to dip into savings or investments just to make ends meet? _____

24. If you wanted to work a few more [or "a few" for non-income earners] hours a week,

Do you think you could find work? Yes____ No____

[If Yes] How much do you think you'd be paid? $_____/HOUR

[Present Card K]

25. NET WORTH means the value of things you own (personal property, automobiles, equity in a residence, investments, savings etc.) MINUS the total amount you owe to others (loans, mortgages, balance owing on credit cards and installment purchases, etc). Please look at the card and tell me which letter best describes your [household's if 19a; personal if 19b] net worth at the end of 1981.

_____[Letter]
_____[Refused, or didn't know and refused to guess].

26. May I please have your name and phone number in case my supervisor wishes to check that I completed this interview.

____

Thank you very much. You have been very helpful.

INTERVIEWER EVALUATION

Record any comments which might help us understand the answers given by the respondent, especially those who protest during the bidding questions.

APPENDIX B: SAMPLING RATIONALE AND PROCEDURES

To obtain contingent valuation responses, 792 households in the Eastern United States were questioned about the value of preserving or improving visibility in the United States. This survey represented the opinions of about 100 million people living in the Eastern U.S. It provided the basic information for a monetary estimate of the value that people in the Eastern U.S. would place on alternative degrees of visibility improvement in their area. Indirectly it provided some clues about how much people in the West might value improved visibility in the Eastern U.S.

In order to enable the 792 households to give us the information we sought from them, it was essential that they be made representative of the population from which they were drawn. Stratified-cluster random sampling was used. There are several reasons for this approach. First of all there is a great deal of diversity in annual average visibility in the area. (See Map A.) Also, there is substantial social diversity among the eastern regions, and they may differ from one another in important ways in their valuation of visibility. Economic theory thells us that geographic and socio-economic differences are important and should be included in the analysis. To make it highly likely that a simple random sample would cover those categories would require a much larger sample than is feasible within the project budget.

The creation of sampling sub-regions was desirable for policy purposes. Pollution control is the means by which visibility can be altered in any region by human choice. However, pollution levels differ substantially from one region to the next. Consequently, any change in ambient air quality standards will affect visibility in different regions differently. Regions that already meet the standard will experience no change in visibility; regions the farthest from compliance will experience the greatest visibility improvement. A sample design that does not permit the analysis of separate regions would not answer the requirements of policy analysis.

To implement the sampling plan, six city areas in the Eastern U.S., in addition to Chicago, were chosen to represent each level of average annual visibility in geographically dispersed areas of the Eastern U.S. The cities were Atlanta, Boston, Cincinnati, Miami, Mobile, and Washington, D.C. Selection of city and rural areas outside the cities created sub-populations within the Eastern U.S. The second major aspect of the sampling plan was to apply random sampling within each urban and rural area. The urban sample in each city area was drawn using 1970 census tract maps and census statistical tables. First, all of the n census tracts in the urban portion of the metropolitan area were assigned numbers one through n . Then twenty numbers between one and n were drawn from a table of random numbers and matched with the corresponding census tracts. Eight interviews were to be taken within each tract, in the order drawn, until 120 interviews were obtained. (The extra tracts were drawn in case eight interviews could not be obtained in some of the tracts. However, the sampling order of the random draw had to be followed; no interviewer discretion was allowed in tract choice.)

Random selection of household <u>within</u> each tract was achieved in a similar way. Every block within each selected tract was assigned a number between one and m , which was matched with the corresponding block number assigned by <u>Block Housing Statistics</u>. A random number between one and m was chosen to determine the block where interviewing started. Additional blocks were determined by the going to the next higher numbered block, using the block numbers given in <u>Block Housing Statistics</u> (returning to the lowest numbered block if necessary).

The interviewer's starting point <u>on each block</u> and the direction to proceed around the block were uniformally specified in advance for all interviewers. The procedure continued until eight interviews were obtained within a tract.

Interviews were conducted in two rural areas outside the metropolitan areas of each city. Maps, interviewing routes and procedures for each area were worked out between the field supervisors and the survey coordinator at the University of Chicago.

Xerox copies of census tract maps and lists of tract orders were provided to all interviewers, with starting blocks clearly indicated. Field supervisors in each city worked closely with interviewers, and monitored their work. The field supervisors all attended a training meeting in Chicago before field work began, and remained in close contact with the U of C survey coordinator during the entire survey period.

Of the 792 households from which questionnaires were obtained, results from 538 were used in the regression analysis for the visibility value function. As indicated in Section 2.4, the major reason for not being able to use all the questionnaires was the refusal of some households to give income and wealth information. Some questionnaires were not used because respondents bid zero for reasons other than how much visibility was worth to them (for example, they said the pollutant rather than the respondent should be expected to pay) or in a few cases unreasonably high bids were given.

This folio explains the visual material used in the contingent valuation survey under USEPA Cooperative Agreement #807768-01-0. The folio contains exact copies of the photographs used. Identification is given on the back of each photograph. The sketches of the Photograph Display Board indicate how the photographs were set up and shown to respondents.

APPENDIX C: BACKGROUND PAPERS

ESTABLISHING AND VALUING THE EFFECTS OF IMPROVED VISIBILITY IN EASTERN UNITED STATES

by

George Tolley
Alan Randall
Glenn Blomquist
Robert Fabian
Gideon Fishelson
Alan Frankel
John Hoehn
Ronald Krumm
Ed Mensah
Terry Smith

The University of Chicago

USEPA Grant #807768-01-0

PROJECT OFFICER: Dr. Alan Carlin
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U.S. Environmental Protection Agency
Washington, D.C. 20460

March 1984

Not for quotation. Empirical results subject to change.

APPENDIX C: BACKGROUND PAPERS

Contents

Introduction to Appendix C

This appendix contains papers which represent the conceptual development during the research effort. Numerous contributions to current economic theory and empirical practice are found in these papers. They represent an exploration of the fundamental issues involved in the visibility project and were necessary in attaining the focus achieved in the final product.

A-1 THEORETICAL APPROACH TO VALUING VISIBILITY

General Framework:

Atmospheric visibility is most effectively conceptualized as a matrix of services provided by atmospheric resources. In order to place the value of atmospheric visibility in perspective, consider the following conceptual model for valuation of atmospheric resources in a benefit-cost context.

In accordance with the potential Pareto-improvement criterion (the generally accepted criterion for benefit-cost analysis--see, for example, Mishan, 1976), an existing environmental resource is valued at the seller's reservation price for a capital good. The capital value of a given environmental resource, for example, "atmospheric resources" (A) which produce a stream of visibility services, is the net present value to the seller of the stream of services in each time period, S_t, where $t = 0, 1, 2, \ldots, \infty$, and the present time period is defined at $t = 0$. Thus,

$$(1) \qquad P.V.\ (A) = \sum_{t=0}^{\infty} \frac{V(S_t)}{(1+r)^t}$$

where $V(S_t)$ = the net value, at time t, of the bundle of services produced by A resources in time t, and r = the discount rate.

The bundle of services, S_t, provided by A resources is a vector of n types of atmospheric services, s_{it}, where $i = 1, \ldots, n$, including those services associated with visibility. Thus,

$$(2) \qquad V(S_t) = \sum_{i=1}^{n} V_{it}(s_{it})$$

Now, let us consider, first, the production of atmospheric services, and, then, the value of those services. The supply of an atmospheric service, s_i (i,. ..,n), in any time period is a function, uniquely determined by geological, hydrological and ecological relationships, of the attributes, a_k (k = 1,...,m), of the atmospheric resources. Thus, for all services in i = 1,...,n, we have

(3)
$$
\begin{aligned}
s_1 &= g_1(a_1,\ldots,a_m)\\
&\vdots\\
s_n &= g_n(a_1,\ldots,a_m)
\end{aligned}
$$

Man enters the production system as a modifier of atmospheric resource attributes. He may do this directly, e.g., by generating residuals and permitting their release as pollutants into the atmosphere. He may also modify atmospheric resources as a side effect (expected or unexpected) of some other decision pertaining to, e.g., the management of solid wastes or water pollutants, or of those resources which influence the capacity of the atmosphere to absorb wastes. For each kind of atmospheric resource attribute in k = 1,...,m, we have

(4)
$$
\begin{aligned}
a_1 &= h_1(n^s,x^u)\\
&\vdots\\
a_m &= h_m(n^s,x^u)
\end{aligned}
$$

where n^S = a vector of "natural systems inputs", i.e., the inputs which would determine atmospheric quality in the absence of man's technology, and

x^u = a vector of inputs controlled by man, e.g., anthropogenic pollutants, and any efforts on the part of man to improve the quality of atmospheric resources.

Both n^S and x^u are subject to scarcity; and the attribute production functions are determined by the laws which govern natural systems and by man's technology. The production system is now complete. It is entirely possible that the levels of production of some kinds of services, s_i, influence the level of some attributes, a_k, by a feedback mechanism wherein s_i alters the level of some man-controlled inputs in x^u. For example, the attempt to enjoy high levels of waste assimilation services involves high level of pollution inputs, which may directly or indirectly modify environment attributes.

Now, consider the value of atmospheric services. Each individual, j, enjoys utility in each time period, t:

(5) $$U_{jt} = f_j(s^g{}_t, z^y{}_t, y^z{}_t)$$

where s^g = a vector of atmospheric services, which are directly enjoyed for their amenity value, including those which contribute to directly enjoyed atmospheric visibility,

z^y = a vector of goods and services for which atmospheric services are inputs, such as outdoor recreation services, and

y^z = a vector of goods and services which are produced in processes bearing no immediate relationship to environmental services.

Each individual makes decisions in the initial time period, and subject to his initial budget constraint, in order to maximize the present value of expected lifetime utility.

By minimizing his expenditures, subject to the constraint that his utility must always be equal to the utility he enjoys with the existing level of atmospheric resources, his Hicksian income compensated demand curves [see Hicks, Mishan, Currie, *et al*.; Willig; and Randall and Stall] for atmospheric services may be derived. From this, the Hicksian compensating measure of the value of the loss which the individual would incur in time t, should the quality of atmospheric resources be degraded--or the value of the gain the individual would enjoy in time t, should the quality of atmospheric resources be improved--can be calculated. The total social loss from a degradation of atmospheric resources--or the benefits from an improvement in atmospheric resources--may be calculated by summing the Hicksian compensating measures of welfare change across individuals and across time periods.

To adapt this general model to the study of the economic value of atmospheric visibility in the eastern United States, account must be taken of several specific factors.

a) Due to the relatively rapid recovery, under favorable circumstances, of atmospheric resources from assaults by pollutants (compared to, say, land and water resources, and complex ecosystems) intertemporal relationships, while significant, may be less important than in the cases of some other kinds of resources.

b) Due to the dominant west-to-east (or southwest-to-northeast) transportation pattern of atmospheric pollutants, welfare impacts (i.e. social costs or benefits) of visibility change in one part of the study area are attributable to antropogenic pollutants generated in other parts of the study area. Analysis by D. M. Rote of ANL long range transport model incorporates these effects.

c) The Primary emphasis of the research on atmospheric visibility has required that considerable subtlety and discernment be applied to the task of differentiating between those welfare effects due to visibility change and those due to other effects of atmospheric pollution (e.g. plant, animal and human health effects). For example, outdoor recreation activities may be adversely affected by visibility degradation, but also by damage to plant communities and fish from acid precipitation; the market value of residential property may be adversely affected by poor visibility conditions, but also by exposure to human health hazards and property damage.

It is also important to note that the same anthropogenic pollutants, interacting with natural atmospheric conditions, responsible for effects on visibility and, e.g., the health of plant communities and human beings.

d) While consistent with the conceptual framework developed here, the research in this report concentrated upon empirical estimation of the relationships expressed in equations (1), (2), (3), and (5), that is, the relationships between changes in atmospheric resource attributes (i.e., various relevant measures of ambient quality) and the value of visibility services provided.

The estimation of the relationships expressed in equation (4)--i.e., the relationships between natural atmospheric conditions, anthropogenic emissions and ambient air quality--will not be a primary focus of the research proposed herein. However, the research is designed to be compatible with estimates of the (4) relationships, which are provided by ANL. In this way, the research makes a major contribution to the understanding of relationships between atmospheric emissions, ambient air quality and the economic value of changes in atmospheric visibility in the eastern United States.

e) The particular atmospheric visibility services which are foci of the proposed research are: (1) Those which contribute to the satisfactions enjoyed by owners and occupants of urban and suburban residential property; (2) those which contribute to the satisfactions of recreationists in urban, mountain, and coastal environments; and (3) those which influence the safety of users of ground and air transportation services (given the hypothesis that atmospheric visibility influences the flow of traffic and the frequency of accidents).

Extended Framework

In this section we expand upon the conceptual framework by further developing the relationships between atmospheric visibility services and utility [equation (5)] and the value of service flows [equation (2)].

There is now general agreement that the change in consumers' surplus is the proper measure of the economic value of a change in the level of provision of a good, service, or amenity [Currie, Murphy and Schmitz; Dwyer, *et al*.; Harberger; Hicks, 1940-41; Hicks, 1943; Hicks, 1945-46; Mishan, 1947-48; Mishan, 1976; Mishan, May 1976; Randall and Stoll; Willig].

The conceptual framework presented below provides a general basis for estimating changes in consumers' surplus resulting from changes in the provision of goods, services and amenities--in this case, those associated with atmospheric visibility--including the marketed and the non-marketed, the divisible and the indivisible, and the exclusive and the non-exclusive [Brookshire, Randall and Stoll]. Consider Figure 1. The origin is at Y^0, Q^0, which represents the consumer's initial holdings of the atmospheric visibility service in question, Q, and "income" (or, more precisely, the "all other goods" numeraire). As one moves to the right on the horizontal axis, the quantity of Q increases; as one moves to the left, Q decreases. As one moves upward, on the vertical axis, "income" decreases; as one moves downward, "income" increases. The total value curve, or willingness to pay curve, passes from the lower left quadrant through the origin and into the upper right quadrant. For an increment in the service from Q^0 to Q^+, the individual is willing to pay the amount $Y^0 - Y^-$, which is a positive amount. After having paid his willingness to pay (WTP) and receiving the increment $Q^+ - Q^0$, the individual is exactly as well off as he was at the origin. For a decrement in the level of provision of the service to Q^-, the individual is willing to pay the amount $Y^0 - Y^+$ and, hating paid that amount and received the decrement, is exactly as well off as he was at the origin. Observe that Y^+ is greater than Y^0. Thus, the individual's WTP for the decrement is a negative number. In other words, the individual is willing to accept (WTA) some positive amount of additional income, along with the decrement in the level of provision of the service.

The total value curve measures the net change in consumer surplus resulting from increments or decrements in the level of provision to the individual of the service in question. If the service is unpriced, the change in consumers' surplus is exactly equal to the value of the increment or decrement [Brookshire, Randall, and Stoll].

This value model is applicable to goods and services which are unpriced, divisible or indivisible in consumption, and lumpy in production being available only in quantities Q^-, Q^0, and Q^+. If the good in question was divisible in consumption, infinitesimally divisible in production, and available in infinitely large, frictionless markets at a competitive price, the total value curve could be replaced with the broken price line (which

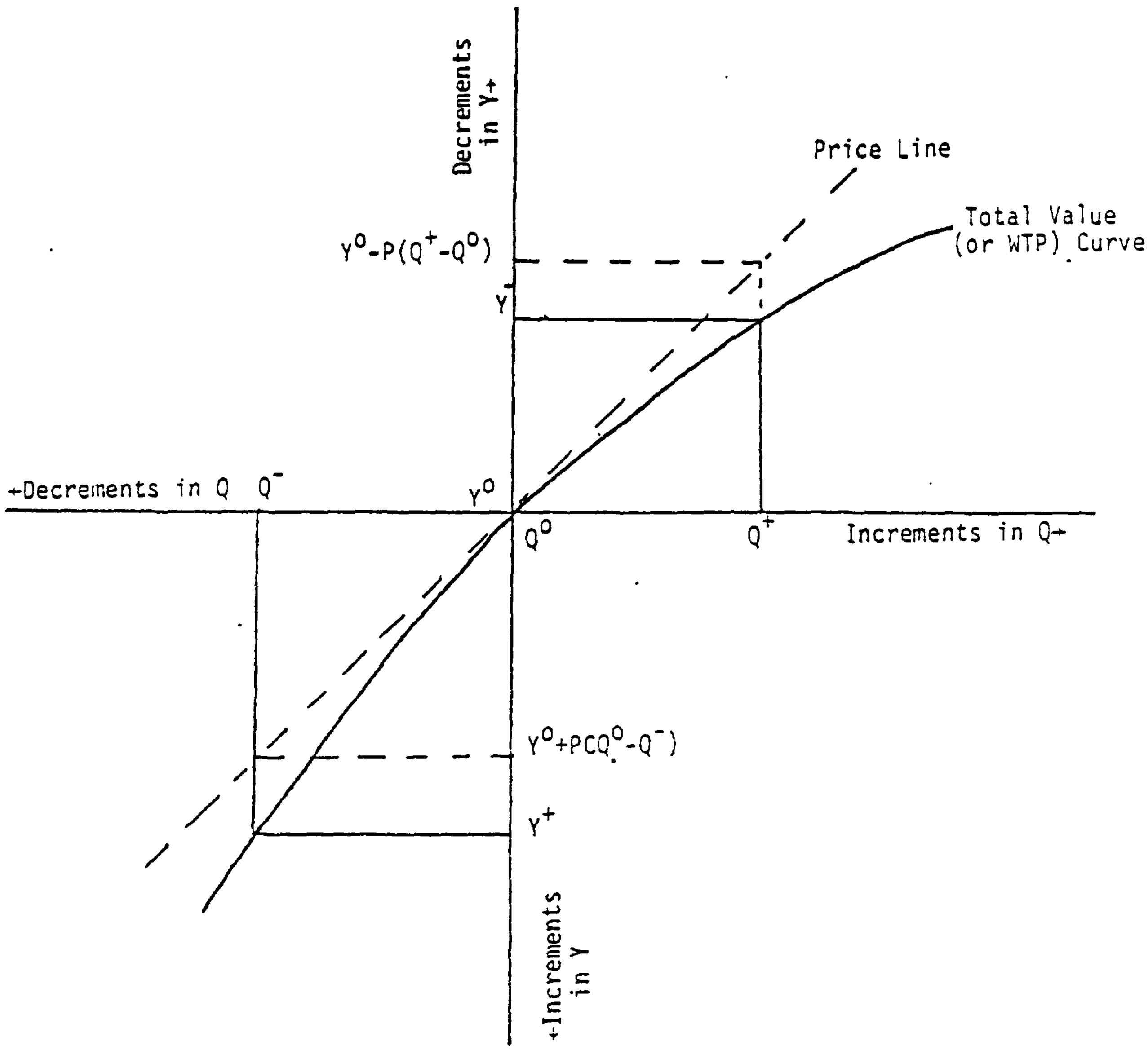

Figure 1. The Total Value Curve.

is tangent to the total value curve at the origin). In such a case, the absolute value of WTP for an increment would be exactly equal to the absolute value of WTA for an equal sized decrement, and both are equal to $P \cdot \Delta Q$ (i.e., the unit price multiplied by the quantity change). Observe that, in cases where the total value curve (rather than the price line) is relevant, WTP for an increment in Q is smaller in absolute value than WTA for a similar sized decrement. Theoretical analyses have developed formulae for the empirical estimation of the difference in absolute value between WTP and WTA in this circumstance [Randall and Stoll; Willig].

The above conceptual framework is entirely general, and develops the relationships between consumer surplus, WTP (and WTA, the counterpart of WTP in the case of decrements in the good), and market price. Where some definable population, e.g., the residents of a given community or the users of a given recreation site, experience the same increment or decrement in the availability, the aggregate value of the change, in benefit-cost terms, is equal to the sum of the individiual values [Bradford, Dwyer _et al_.].

The value of increments or decrements in atmospheric visibility services (the v_{it}, of equation 2) were estimated, using various techniques, but always in a manner consistent with the above conceptual framework. In those cases where competitive markets exist for atmospheric visibility services, market observations were analyzed in order to permit estimation of the value (i.e., price) of visibility services. Where atmospheric visibility services are not directly marketed, two general classes of analytical techniques for value estimation are available.

a) Hedonic methods utilize observations from markets in goods or services which bear some relationship to visibility services (e.g. are jointly consumed with visibility services, or are produced in processes which require visibility services as inputs) in order to estimate implicit prices or values for visibility services. This class of techniques includes the land value method of valuing environmental amenities [Abelson; Anderson and Cracker; Brown and Pollakowski; Maler]; the hedonic and household production function methods [Deyak and Smith; Muellbauer; Pollak and Wachter; Rosen], which have been applied to valuation of a wide variety of non-market goods including human health and safety; and the travel cost method which has been widely applied in the economic valuation of outdoor recreation amenities [Brown, Singh, add Castle; Cesario and Knetsch; Clawson and Knetsch; Gum and Martin; Knetsch].

b) Contingent valuation (CV) methods approach the valuation of non-market goods directly by creating hypothetical markets and treating the decisions of respondents or experimental subjects using these hypothetical markets as values which exist, contingent on the existence of hypothetical markets [Brookshire, Ives and Schultze; Bishop and Heberlein; Brookshire, Randall and Stoll; Davis; Hammack and Brown; Randall, Ives and Eastman; Randall *et al*.; Smith].

Overview

To estimate the change in aggregate consumer's surplus resulting from changes in average or typical visibility situations were identified that are affected by changes in the level of services rendered by visibility. A major consideration in the research design was to include situations where visibility effects are likely to be most pronounced where they are likely to have significant influence on benefits due to the numbers of people or the value of property affected. With situations identified, an appropriate valuation method was selected and the change in consumer's surplus estimated. Table 1 presents the results of such an identification process for Chicago. Examining Table 1, the first column gives a taxonomy of situations that are, to a greater or lesser extent, hypothesized as being affected by the level of visibility. Columns adjacent to the first in Table 1 match at least one valuation technique to each category of identified situations. Wherever possible, more than one approach is matched to a situation so that valuation results may be replicated and compared. Both the taxonomy of situations and also the data required for the valuation of effects are discussed.

Using the contingent method, visibility levels for a given situation were described in both narrative and photographs. By carefully structured questioning, an individual's valuation of a given increment of visibility was then elicited. The method was contingent because valuations were contingent upon an individual's behavior in a hypothetical choice situation. The contingent method was administered directly to individuals. The

Table 1. Situations Affected by Visibility and Methods of Valuation for Chicago

SITUATION	VALUATION METHOD			
	Contingent	Revealed		
		Hedonic	Demand	Cost of Inputs
I. Aesthetic or View Related				
A. Urban Visibility Services	X			
1. Residential				
a. Lakeshore residences	X	X		
b. Non-Lakeshore city	X	X		
c. Metropolitan suburbs	X			
2. Non-Residential				
a. Workplace				
i. Loop area (First National Bld., Stan. Oil Bld., etc.)	X	X		
ii. City, non-loop (Oakbrook)	X	X		

Table 1, continued

SITUATION	VALUATION METHOD			
	Contingent	Revealed		
		Hedonic	Demand	Cost of Inputs
b. Commuting and other intra-urban travel				
i. Expressways (Kennedy, Eisenhower, etc.)	x			
ii. Bridges (Chicago Skyway)	x			
c. Recreation				
i. View Primary				
a. Hancock Tower	x (Consent)		x	
b. Sears Tower			x	
ii. View Secondary				
a. Spectator Activities			x	
b. Participatory Activities	x			
iii. Substitutes			x	

Table 1, continued

SITUATION	VALUATION METHOD			
	Contingent	Revealed		
		Hedonic	Dernand	Cost of inputs
B. Rural Visibility Services	X			
1. Residential	X			
a. Michigan City, Indiana				
2. Recreation	X		X	
b. Indiana Dunes State Park				
II. Non-View Related				
A. Effect on Traffic Flows				X
1. General Aviation				
a. Delays				
b. Cancellations				
2. Commercial Aviation				X
a. Delays				
b. Cancellations				

Table 1, continued

SITUATION	VALUATION METHOD			
	Contingent	Revealed		
		Hedonic	Demand	Cost of Inputs
B. Safety Related				
1. Air Traffic				X
a. Single plane accidents				
b. Multi-plane accidents				
c. Near-misses				
2. Ground Traffic				X
a. Highway accidents and collisons				
III. Option and Existence Value of Visibility				X
A. National Landmarks				
1. Washington Monument				
2. Statue of Liberty				
3. National Parks				

revealed behavior methods relied upon an individual's actual behavior for evidence in valuation. Because actual behavior may be only indirectly related to visibility, revealed behavior approaches confronted both conceptual and statistical difficulties on application. Of the revealed behavior methods, the hedonic technique values visibility as a characteristic of property. Property values as well as supplementary information on housing and view characteristics were required for valuation. The demand method measured the effect of visibility on demand for activities such as outdoor recreation. To apply the demand method, only secondary data on attendance was required in most cases considered below. inally, the opportunity cost-of-inputs method was applied to situations or events that occur only sporadically and thus did not generate sufficient data for any of the other techniques.

Examining Table 1 once again, the broadest distinction of the types of situations affected by visibility is between those situations in which visibility affects aesthetic appreciation and those situations where the effect is not directly aesthetic. The aesthetic or view-related effect was further distinguished by demographic area: by urban and non-urban or rural visibility services. Using the contingent valuation technique, both urban and rural visibility services were valued directly by observing residents in both urban and rural areas. In the Chicago area, urban visibility services were valued directly. Three strata correspond to the three divisions under residential urban visibility services: lakeshore residents, non-lakeshore city residents, and residents of the metropolitan suburbs. The approach had three purposes. First, using a set of photographs and the contingent technique, a valuation of visibility increments over the entire urban area was elicited. This first valuation was for urban visibility services as a whole. Second, the CV instrument elicited information on housing and view characteristics. This information was required for the hedonic approach to valuation. Third, the CV instrument inquired about recreational activities. Such participation data were essential to population estimates for the non-residential effects of urban visibility services and their aggregation.

The third major effect of visibility within the metropolitan area is on urban recreation. Two types of affected recreation activities can be distinguished. The first is recreation that focuses on the enjoyment of specific views. The second is recreation in which a view and associated visibility level are only secondary, used mainly as a background. Within Chicago, the two major view primary sites are Hancock Tower Observatory and the Sears Tower Skydeck Observatory. Each of these locations offers views of Chicago at various levels of visibility to approximately one million visitors a year. Hancock Tower cooperated with our demand approach to valuation by sharing attendance records. Attendance records were analyzed along with airport visibility and weather data to determine the effect of visibility on visitations. Finally, a contingent valuation of visibility was conducted at the Hancock Tower. To elicit a valuation of increments or decrements of visibility at the Hancock Tower, a special CV instrument was constructed for those who visit the Tower.

Valuation of the effect of visibility on the enjoyment of spectator sports was made by the demand method. Fist, attendance data was regressed on weather, visbility, and other secondary data to determine the effect of visibility. The effect of visibility was shown to be significant in preliminary analysis and a more complete demand model was specified for the valuation of its effect. This more complete demand model included equations for local substitutes to outdoor recreation, such as museum and aquarium attendance.

The non-aesthetic effect of visibility on general aviation and highway accidents were also examined for the Chicago area. These are discussed in the chapter on secondary data analysis.

To extend the valuation of visibility beyond the Chicago region and thus permit a benefit estimate for the eastern United States as a whole a valuation of visibility services were made for six other population areas. The same basic approach used for the Chicago area also was used for these six additional population areas. That is, both contingent and revealed behavior methods were applied to value the effect of visibility in each of the situations outlined in Table 2. The six additional population areas chosen for investigation were selected on the basis of experience regarding the prevailing visibility conditions over different zones within the eastern United States, and the requirements of a systematic aggregation procedure.

Selection of the areas entailed references to median yearly visibility . Over the eastern United States there exist several distinct visibility zones. Except for the Mississippi delta area and the Ohio River basin, median visibility from the Appalachian

Mountains to the plains states is approximated by that of Chicago. By sampling from urban and rural areas near Cincinnati, for example, information was obtained regarding the value of visibility for an inland area of generally poor visibility. By sampling from urban and rural areas in and near Boston, information was obtained regarding the value of visibility for a coastal area of generally good visibility. A sample from the area of Atlanta provided information regarding the value of visibility by residents of a median range visibility zone for an inland city of the south.

Benefits as Measured in Housing Markets

Housing markets can yield useful information about the demand for goods such as clean air and visibility which are not traded in their own explicit markets. Analysis of markets, whether they be explicit or implicit, has great appeal relative to non-market benefit measures because it is based on observable behavior where preferences are revealed through some monetary expenditure rather than through an imaginary response to a hypothetical situation. Nonetheless, since the Ridker and Henning (1967) and Anderson and Cracker (1971) studies of residential property values and air pollution doubt has arisen as to exactly what information is contained in a regression of property values on characteristics of housing, i.e., a hedonic regression. Maler (1977) points out the value of any estimates based on analysis of property values is limited by potential malfunctions in the housing market which might be caused by lack of information about the costs of air pollution, in particular, or all factors which cause the market to be in a state which differs from equilibrium attained under ideal conditions of zero information, transactions and adjustment costs, in general. Such criticism depicts the trade-off inherent in the alternative methods of benefit estimation, market and non-market, and suggests the importance of using them as complementary inputs into benefit estimation.

While criticism of housing market studies remains, considerable progress has been made. Due largely to contributions by Freeman (1971) and Rosen (1974), it is clear that a hedonic regression does not yield a useful measure of benefits--at least directly. Rosen's conceptual framework for analysis of implicit markets shows that a hedonic regression is a market clearing function yielding only hedonic prices which then must be used along with other determinants of demand to estimate the demand for traits implicitly traded in the housing market.

Using Rosen's approach housing is viewed as a package of traits made up of both structural characteristics and neighborhood amenities. Households respond to the configuration of traits in addition to the traits themselves since the traits are not easily repackaged. Since households demand housing, not land, they consider various structures in various neighbodhoods and choose housing packages which must suit them. As such, household utility depends on housing, market goods and tasts or:

$$(1) \qquad U = U(Z,X: T)$$

where U is household utility, Z is a vector of housing traits, X is a vector of market goods and T is a vector of taste variables. Household utility maximization is constrained by the available money income:

$$(2) \qquad I = X + P(Z: I,U,T)$$

where I is household money income, X is the numeraire, and P(Z: I,U,T) is the household's total valuation of housing traits which depends on the housing traits, income, utility level and tasts, respectively. The valuation function gives an indifference map depicting the willingness of the household to trade off units of market goods, X, for incremental additions of any housing trait, Z, given income, utility and tastes. As Rosen shows the valuation function has the properties that it is increasing at a decreasing rate with trait consumption, i.e., $\partial P/\partial Z > 0$ and $\partial^2 P/\partial Z^2 < 0$, and that the ratio of marginal valuations of traits equals the ratio of marginal utilities of traits for each pair of traits, i.e., $P_i/P_j = U_i/U_j$ where P_i is the marginal valuation of trait i and U_i is the marginal utility of trait i, etc.

The household faces a market equilibrium price function, P, which indicates the amount of market goods which much be paid for additional housing traits. If consumers have approximately zero market weights and the market clearing price function is exogenous to the household this price function for packages of housing traits is:

$$(3) \quad P = P(Z)$$

where P is the price of the factor of traits, Z. The partial derivative of the market price function with respect to a trait, P_i, gives the equilibrium marginal price of Z_i which is often called the hedonic or implicit price.

Given that households maximize utility in a way similar to that when they face a linear budget constraint, the first order conditions yield demand function for housing site traits:

$$(4) \quad Z_i^d = Z_i^d(P_1, \ldots, P_i, \ldots, P_n, I, T)$$

where the quantity demanded of trait i depends on its own marginal price, P_i, the marginal prices of complementary and substitute traits, P_j for $J = 1, \ldots, n$ and $J \neq i$, household income and tastes.

To estimate the demand for visibility, or clean air, we first estimate the price of clean air. The price is implicit in the hedonic regression in that is is the partial derivative of housing price with respect to clean air. If the true functional form of the hedonic regression is nonlinear, then the marginal price of clean air will vary across sites. Second, we use price of clean air along with the prices of complements and substitutes income and taste variables as well as whatever else is necessary to identify demand to estimate the demand for clean air in the usual manner.

Recent empirical studies demonstrate that the theoretically-preferred approach is feasible and that it does yield benefit estimates which differ from those based only on the hedonic regression, Harrison and Rubinfeld (1978), Nelson (1978), Brookshire *et. al*. (1979), and Bender *et. al*. (forthcoming) all estimate the demand for clean air applying Rosen's model. Linneman (1977), Blomquist and Worley (1978) and Witte *et. al.* (1979) estimate the demands for housing traits other than clean air. A pattern which emerges is that the estimates from a hedonic - demand, i.e., two-step, approach differs from the simple hedonic estimates. Harrison and Rubinfeld find that the simple linear hedonic overestimates the benefits of cleaner air by approximately 42% while Brookshire *et. al.* find the linear hedonic overestimates the benefits by approximately 1594. Bender *et. al*. also find that linear hedonic is quite misleading, but, in contrast, it *under*estimates the benefits by approximately 60%. Blomquist and Worley find that the linear hedonic overestimates benefits for some housing traits and underestimates benefits for others. While each of the four studies indicates the superiority of a Rosen approach, the last two emphasize the importance of a systematic search for the best functional form of the hedonic equation, e.g., using a Box-Cox maximum likelihood procedure for searching transformations of variables in the hedonic equation. These recent contributions were carefully considered in our estimation of the demand for visibility.

Our estimates of benefits of greater visibility more fully exploit the gains of the Rosen procedure by paying particular attention to the estimation of total social benefits from the demand equations. Previous benefit estimates have been made by simply multiplying the benefit for the typical household times the number of households benefiting from the improvement. This estimation is appropriate for marginal or nonmarginal changes for the typical households. However, this does not yield true benefits for all if those consuming some amount other than the average (typical) amount of clean air (or any other trait) do not have demands symetrically distributed about the demand for the typical household. For example, those with higher incomes will value the cleaner air more than those with average income and those with lower incomes will value the cleaner air less than those with average incomes. The values of higher income households are unbounded, but those of lower income households are bounded below by zero. In this case, simple aggregation can lead to an overestimate of total benefits. Harrison and Rubinfeld do consider three income subgroups and find that indeed the total benefits are less than those estimated by simple aggregation based on average income. We used distributions of demand shifters, such as income, representative of the eastern portion of the United States to aggregate household benefits. This not only includes the valuations of these households not observed at the margin consuming the average amount of clean air, but adjusts for any differenes between particular areas studies and the entire region.

A.2 ATMOSPHERIC VISIBILITY AND CONTINGENT VALUATION EXERCISES

A decade has passed since the initiation of the research which provided the data base for the first contingent valuation study of aesthetic aspects of air quality to gain respectability among economists (Randall, Ives and Eastman). In that time, the theoretical basis of contingent valuation has been clarified (see Brookshire, Randall and Stoll for an exposition of current theory, and Randall, 1980 manuscript, for the theoretical relationship between contingent valuation total cost, property value, markets in substitutes, and hedonic methods of valuation); contingent valuation formats have been classified, codified, and accepted for use in benefit cost analysis of federal water projects (U.S. Water Resources Council); and a growing number of studies applying various contingent valuation formats to a wide variety of nonmarketed goods have been completed and published.

Contingent valuation (CV) methods have always encountered some skepticism from economists, since the basic data used are not generated by actual transactions in near-perfect markets. Nevertheless, opposition to the use of such techniques--or, perhaps, to the attribution of respectability to them--has noticeably softened in recent years (see, e.g., Freeman). Skepticism seems to have been undermined by several developments: the above-mentioned work in developing the theoretical relationship between consumers' surplus concepts, non-exclusive and nonrival goods, and contingent valuation methods; the fairly precise replication of earlier CV results in later exercises (Rowe, d'Arge and Brookshire); and the fairly general finding of similar results when CV methods are compared with travel cost (Knetsch and Davis) and property values (Brookshire, d'Arge, Schules and Thayer) methods.

Nevertheless, some doubts remain. (1) The generally accepted theory of "public goods" (Samuelson) indicates scope for strategic behavior, in which individuals avoid revealing their true valuations of such goods in order to maximize their surplus, i.e., the difference between the value they enjoy and the contribution they make. For some economists, the scope for such behavior is prima facie evidence of its prevalence; hence, a general refusal to take seriously the results of any CV method which fails to eliminate that scope. The search for "incentive compatible demand-revealing mechanisms" is in part a response to the "scope proves prevalence" argument. For others, the prevalence of such behavior is much more problematical: while no country seems to rely on voluntary taxation, many "public goods" are, in fact, voluntarily provided in substantial (but not necessarily efficient) quantities. Smith assembles impressive experimental evidence that, at least in the kinds of circumstances he and others he cites have studied, strategic behavior is simply not a significant influence on aggregate valuations.

(2) In an interesting recent experiment, Bishop and Heberlein created an experimental market in which they actually purchased goose hunting permits from permittees, effectively establishing in real transactions the WTA of hunters to forego the hunting season. In a mail survey conducted at about the same time, WTP for hunting permits was established via single (i.e. non-iterative) questions asking respondents to nominate a dollar amount which

represents their maximum WTP. It turned out that WTA established in actual transactions was about three times WTP generated in the survey, a difference far greater than can be explained by income effects (Randall and Stoll, 1980a and b). There are good reasons to suspect the Bishop-Heberlein WTA experiment of upward bias, while their WTP survey used a format which I consider inferior to the iterative bidding routine (Randall, 1980 manuscripts). Nevertheless, the various possible biases are probably not sufficient to account for all of the observed differences. Tentatively, it can be concluded that WTP surveys such as that conducted by Bishop and Heberlein may typically generate understimates of the “true” value of the good concerned. The temptation to overstate the WTP knowing that one is unlikely to be forced to actually pay the stated amount (the “strategic bias” most commonly attributed by economists to this kind of CV exercise) seems to be more than counterbalanced by a tendency to respond ultra-conservatively to the suggestion that one may be expected to pay for goods which are customarily non-marketed (or to pay substantially more for goods which are customarily underpriced by public institutions). The conclusions stated immediately above are tentative; a firmer conclusion is that the Bishop-Heberlein experiment raises, in a dramatic way, some serious questions about the quality of data generated in direct question CV exercises.

(3) Those researchers who have attempted to estimate statistical relationships which use various economic, social and demographic variables to explain the individual WTP bids generated in CV exercises have typically been disappointed by the results (Cicchetti and Smith; Eastman, Hoffer and Randall; Brookshire, d’Arge, Schulze and Thayer). The recent work by the University of Chicago and the University of Wyoming teams in this and a closely related study has encountered similar frustrations.

While there is abundant and convincing evidence that individual WTP bids are not merely random numbers, researchers have not been notably successful in finding relationships between individual bids and variables describing the individual’s economic, social and demographic condition, In estimated equations, the adjusted R^2 is often low and few variables are related to individual bid in a statistically significant way. Sometimes, even the relationship between individual bid and individual income is not significant. These kinds of results are unsettling to those who believe that, if individual bids are in fact "good" economic data, they should be related in systematic ways to the kinds of variables are related to individual bid in a statistically significant way. Sometimes, even the relationship between individual bid and individual income is not significant. These kinds of results are unsettling to those who believe that, if individual bids are in fact "good" economic data, they should be related in systematic ways to the kinds of variables which often successfully explain demand and/or value data for marketed goods.

This issue has several vantage points.

(a) Perhaps it is unreasonable to expect to be able to obtain strong statistical relationships, using individual observations obtained from small samples. After all, most demand studies use observations of broad aggregates (time series of aggregate sales and/or cross-sections of total sales by state, SMSA, etc.). Surely, the explanation of individual variables is a task of quite a different order.

It has been observed that demand analyses using individual data generated from panel studies have generally yielded more robust statistical relationships than have WTP exercises. But, these studies typically use much larger panels than most WTP survey samples, and (2) they typically deal with fairly broad categories of regularly purchased foods (e.g. “food” or “meat”) whereas WTP studies often deal with highly specific goods (atmospheric visibility at some specific place, elk hunting in a particular kind of terrain in a given state or sub-state region).

Brookshire, Randall and Stoll report obtaining considerably more robust equations--not merely higher R^2, but also highly significant income relationships--when they grouped their sample of 58 respondents into 4 classes, according to household income, prior to the analysis. This procedure suppresses within-group variation (presumably diminishing the influence of a few “extreme” observations in a small sample). Statistically, the apparently improved estimates and lower mean square error were obtained at the cost of higher principal diagonal $(X'X)^{-1}$. Thus, their procedure may not necessarily be viewed as attractive

(b) Perhaps WTP vids, viewed as cardinal indicators of dollar valuations, are not especially reliable. Different individuals probably perceive the offered good (e.g., a given increment in atmospheric visibility) differently. On this front, progress has been made (as Freeman acknowledged) via the use of standardized photographs and devices to improve uniformity of perception. Nevertheless, problems remain. In the case of atmospheric visibility, no amount of effort in standardizing the verbal and visual information provided to respondents can overcome different perceptions due to individual differences in visual acuity.

A.3 AN EARLY CONTINGENT VALUATION EXERCISE

1. Pretest: Chicago Residents

In order to pretest the basic instrument for subsequent contingent valuation exercises and to explicitly field test certain innovations in C.V. instrument design, a C.V. exercise was conducted in Chicago and suburbs. Sixty-eight households participated. After rejecting 15 observations (apparent enumerator bias), 2 (outliers) and 8 (self-identified protest bids) all subsequent analyses were based on 43 observations.

The basic instrument tested included the following elements:

- questions designed to test the efficacy of color photographs in in representing visibility levels.
- alternative methods of defining and representing visibility levels.
- a listing of activities in which the household participates.
- questions exploring whether visibility conditions influence choice of activities and, if so, in what ways.
- questions to determine whether the household owned certain equipment used in producing activities for which visibility is an input.
- WTP questions
- follow-up questions to identify protest bidders and obtain participant's evaluation of the C.V. exercise.
- home ownership v s. rental.
- view quality at the home.

-expected period of residence in Chicago SMSA(i.e., short-term, . . . , through retirement).

-demographic information

-questions to probe the notions of life cycle consumption, permanent income, and marginal wage-cost of leisure-time.

All of these elements were serious candidates for inclusion in subsequent C.V. work.,

Four kinds of innovations in C.V. instrument design were explicitly tested:

a). WTP Instrument

Earlier C.V. work under this project and published research suggested that the iterative bidding format is more effective than single question formats which ask the participant to simply state his/her WTP or to select from an array of numbers that which best represents WTP.

Recent work at Resources for the Future (Mitchell and Carson, draft report) used a payment card, on which typical household annual costs--$ in taxes and higher prices -- for various public programs were stated. Participants were asked to examine the data provided and then state their WTP for improvements in water quality. Mitchell (personal communication, and draft report) reports that he considers the payment card device sucessful.

For the pretest, we developed a "modified payment card and rebid" format. The payment card was modified to include typical expenditures for both public programs and private goods. About ten minutes after the payment card was used to obtain WTP, the participant was asked “if the program to improve visibility actually cost (stated WTP plus $25), would you accept or reject the program?" This question was re-iterated with sucessively higher cost amounts until a "reject" response was given,

The two WTP instruments tested were:

-iterative bidding ($/month)

-modified payment card and re-bid ($ annually).

On an annual basis, the predicted household bid was $109 higher with the "modified payment card and re-bid" device than with the iterative monthly bid (Table 1, model 1). Only about $20 of the difference was attributable to the re-bid. It was notable that "zero" bids were much less frequent with the "modified payment card and re-bid" device - 7% of all bids as opposed to 39 percent with the iterative bid (Table 2). This explains much of the difference in predicted household bids.

b). Definition of Visibility Levels

Previous work has used color photographs depicting various visibility levels, and defined visibility programs as improving typical visibility from, e.g., the level shown in photo set D to, e.g., the level shown in photo set A. The notion of typical visibility is easy to communicate, but may be an overly simplistic specification of visibility.

Within any year, emissions and background visibility exhibit considerable day-to-day and week-to-week variability. Thus, the relative frequency of good, moderate and poor visibility days may be a more realistic way to specify visibility conditions. A program to improve visibility would increase the relative frequency of good visibility days while reducing that of poor days.

The worst visibility days tend to come clustered together, as ambient pollutants accumulate during periods of air stagnation. Conceptualized in these terms, a program to improve visibility would reduce the length of the longest run of consecutive poor visibility days in a typical year.

The pretest was designed to examane the effectiveness of these alternative ways of communicating visibility conditions. Three specifications of visibility improving programs were used:

-typical visibility would be improved from level B (about 12 miles) to level C (about 30 miles): VISTYP.

-the frequency of various visibility levels would change from 30 percent A (about 4 miles, 40 percent B and 30 percent C to 10 percent A, 30 percent B and 60 percent C: VISFREQ.

-the length of the longest run of consecutive days like A in a typical year would be reduced from 12 days to 4 days: VISRUN.

The predicted annual household WTP was lower with VISFREQ and VISRUN than with VISTYP, but the differences were not statistically significant. VISRUN generated a greater proportion of zero bids than VISTYP.

These findings suggest that, while all three visibility specifications seemed to communicate effectively, VISFREQ and VISRUN offered little advantage over VISTYP. Since VISTYP was more readily related to existing data series on observed visibility, VISTYP was used in subsequent C.V. work.

c). Income Concepts

It is expected on conceptual grounds that WTP bears a positive and significant relationship to household income. This expectation has been borne out in previous published reports, although some small-sample studies have reported insignificant income coefficients.

In this pretest, we took the opportunity to explore ways to improve the specification of income concepts, as follows:

-the notion of standard of living, SOL, which adjusts household income for household size to permit comparability of standard of living across households of varying sizes (Lazear and Michael, American Economic Review, 1980)

-permanent income notions, which were implemented by identifying those households which had recently experienced significant changes in income level, and those which expected to experience such changes within the next five years.

-the notion that for some life-cycle stages annual consumption is more representative of standard of living than annual income. For example, some households of retired persons may consistently dissave or disinvest in order to maintain current consumption.

-the marginal wage-cost of leisure-time, which is an important variable when the demand for visibility is modeled in a household production function framework.

No difficulties were encountered in obtaining the necessary data to specify these various concepts. SOL proved an effective specification of household Income (Table 1). Preliminary analyses (not presented) suggested that permanent income concepts are significant with a larger sample of households. The pretest sample included very few cases of dissaving, thus providing no opportunity to examine the usefulness of this concept in statistical estimation of bid equations.

d). <u>Activities</u>

The household production function framework conceptualizes visibility as a non-rival input in the production of activities which provide utility-gneerating characteristics. To implement that framework, it is necessary to identify:

-the activities which households produce,

-the role of visibility in the production of those activities, and

-the purchased inputs, e.g., equipment, which are used along with visibility in activity production: ACTEQ.

No difficulties were encountered in obtaining data on activities produced and ACTEQ. We were less successful in obtaining data to help specify the role of visibility in activity production. Enumerators and participants reported that section of the instrument was tedious. ACTEQ is an important variable in WTP equations.

Pretest Result

Predicted annual household WTP for visibility improvements in the Chicago region ranged from $125 (with MIB, VISFREO instrument) to $325 (with a AMPCR, VISTYP instrument).

A.4 ECONOMICS OF VISIBILITY - AN INPUT APPROACH

Several recent studies have dealt with both the theory and empirical results of the issue of the value of visibility. Particularly noteworthy are Brookshire et al [1979] and the references cited there, and Rowe et al [1980] and the references cited there. Indeed, Brookshire et al contains a solid theoretical basis for valuing visibility using the concept of the willingness to pay approach. In this section we first discuss the consumer surplus-equivalent variation and compensating variation issues. We then go on to critically evaluate the willingness to pay approach, arguing that it results in values of both visibility and vistas, since they are used simultaneously as inputs in the production of consumerable service.

The Model

Let's assume the existence of a vista, located at a particular site in the city. It can be located either offshore on the lake, or be the lake itself. We define visibility as the possibility of being able to see this site. We define a product, immediately consumed by the viewer, as a function of the site, the conditions which allow it to be viewed, and personnal inputs. Hence,

$$V_{1htj} = f(S_j, W_{1ht}, PI)$$

where V_{1ht} is the quantity of viewing services obtained per unit of time at location 1, hour h and time t, when viewing site S_j. S_j stands for site j ad includes its particular characteristics such as its height, shape, and colors. W_{1ht} are the viewing conditions at location 1, hour h and time t. Note that 1 embodies the height of the observation point, distance from the site, direction to the site and other characteristics one of which might be the existence of buildings located between the viewer and site j which, by obstructing the view, pushes W_{1ht} to zero. The traditional assumptions,

$$f(0, W_{1ht}, PI) = f(S, 0, PI) = f(S, W_{1ht}, 0) = 0$$

$$f_1 > 0, \quad f_{11} < 0, \quad f_2 > 0, \quad f_{22} < 0$$

hold for this production function. As already noted, V_{1htj} is consumed and produced simultaneously (the only way to transfer it from one time to another is by using the storage device known as memory which often has limited capacity). If stored, the quantity of services retrieved from storage (memory) declines by a rate of s per unit of time. Thus, if retrieved at t, the maximum of services retrieved are given by the equation:

$$V_{1ht_0} \cdot e^{-s(t-t_0)}$$

Furthermore, discounting future utility by a rate p, the present value of producing and inventorying visibility services of quantity V_{1ht_0}, is

$$\int_{t_0}^{\infty} U_V^t e^{-(s+p)t} \cdot V_{1ht_0} dt \quad \text{where } U_V > 0, \quad U_{VV} < 0.$$

The above discussion suggests that the particular nature of the product "viewing services" is of the form of a durable with a relativly long life span (as, for example, “I visited the Grand Canyon only once, but I still remember 'every' detail"), although some might depreciate rapidly. [1] Also, there is still the need for proof (although not by ec-

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[1] This depreciation is frequently supplemented by taking pictures of a particular site or scene. The “quality” of the picture, as does the quantity of viewing services, depends upon the conditions of visibility, W_{1th} (Another supplement is picture taking by a different individual, however, this won’t be discussed here).

onomists) that W_{1ht} affects the durability of the product, i.e.

$$s = g(S_j, W_{1ht}, PI)$$

and again,

$$g(0, W_{1ht}, PI) = g(S_j, 0, PI) = g(S_j, W_{1ht}, 0) = 0$$

$$g_1 < 0, \quad g_{11} > 0, \quad g_2 < 0, \quad g_{22} > 0.$$

Hence, the life time returns from the investment of time and money in the production of viewing services is given by

$$\int_{t_0}^{\infty} U_V^t \cdot e^{-[g(S_j, W_{1ht_0}, PI) + \rho]t} \cdot V_{1ht_0} dt.$$

The fact that one is in a certain viewing position at a given site j, implies that some fixed costs have already occured. The time spent selecting the visibility conditions and the viewing position characteristics determine W_{1ht} and thus V_{1htj}. The search for the best spot from which to view site j is analagous to the purchase of more inputs in order to increase V (S_j is a fixed factor). This search clearly involves costs such as time and other expenditures. The relevant question is how much is one willing to pay for the marginal increase in W?

On Willingness to Pay and Consumer Surplus

Frequently, one can not control W. One can, however, control PI. An optimal PI at the margin yields its marginal costs. In addition, for a given S_j, W and PI are substitutes (in a two input model). At this stage we leave the production framework and shift the analysis to a consumer choice model (recall that production and consumption are simultaneous).

Vistas are consumerable goods. We also assume that they are normal goods. Thus, if visibility conditions are a non-inferior input, their derived demand curve is downward sloping (demand for an input, i.e. their marginal value product). We distinguish between two types of demand curves - both extracted from consumer behavior. One is the regular Marshallian demand curve, along which full income is kept constant but utility is allowed to vary; and the Hicksian income compensated demand curve along which full income varies but utility is held constant. Usually, this distinction is made for a good that is explicit in the utility function. We argue legitimacy for the case of visibility given that the producer is the consumer, i.e. the simultaneity of activities and identity of quantities both produced and consumed.

We apply similar reasoning in the case of the quantity of visibility services, W, and the price (implicit) of visibility services, P_W. Accordingly, in Figure 1, we have drawn three demand curves (following Willig [1976]): AA is the Marshallian curve, BB is the income compensated demand curve at utility level $U0$, and CC is simply BB for a different utility level, U^1, such that $U^1 > U^0$ (see also Appendix A). Let M denote money income. Then in Figure 1, the area P^0P^1ac is the conventional measure of consumer surplus, A; P^0P^1bc measures the compensation variation, C, for $U(P^0, M^0)$; and, P^0P^1ad measures the equivalent variation, E, for $U(P^1, M^0)$. Again following Willig, we assume W to be a non-inferior purchased input, such that the inequality, $C \geq A \geq E$, holds. Hence, if a market for W existed, and prices varied between P^0 and P^1, changes in consumer surplus can be calculated. The more pertinent issue, however, is how to handle non-market inputs. In addition to being a public good, the quantity of viewing services, not price, is fixed exogenously for a given pro-

Figure 1

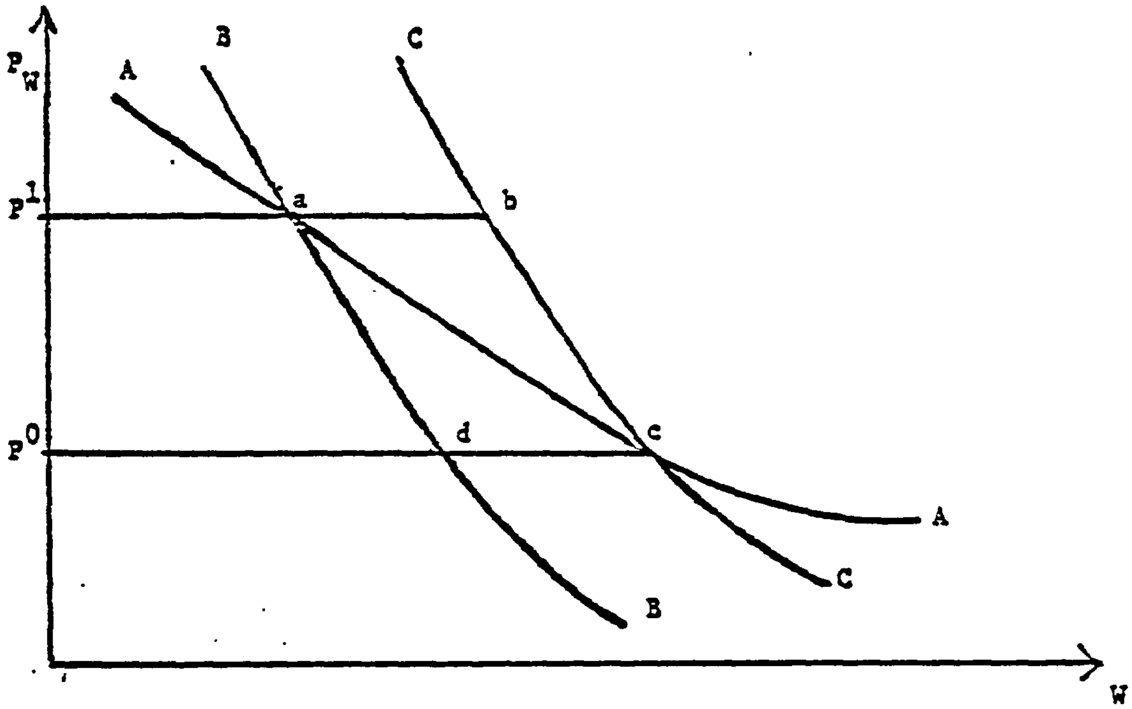
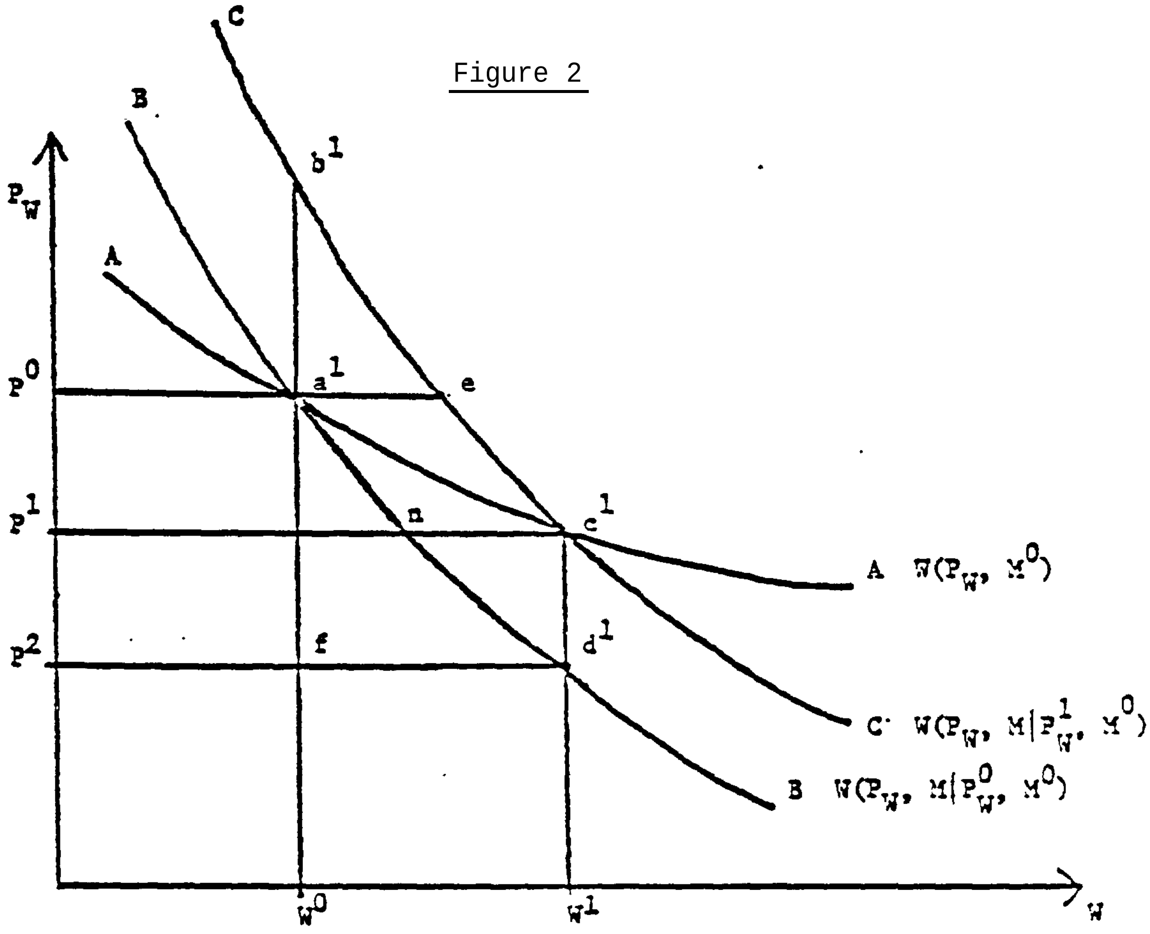


Figure 2



ducer. Furthermore, these quantities may be noncontinuous. In the following section the traditional consumer surplus equivalent variation and compensation variation concepts are applied to exogenous changes of the quantity. If one could find the price (shadow price) the consumer would be willing to pay per unit of visibility directly (whether by questionnaire or by market observations), then the consumer surplus could be approximated. However, this approach is usually not feasible and one has to resort to other methods. (In the last section, we discuss, with some skepticism, the success of the presumably correct willingness to pay method).

BB in Figure 2 is a derived demand curve. When the quantity of visibility services, given free of charge, increases from W^0 to W, the area under the curve increases by $W^0a^1d^1W^1$, which is the measure of the equivalent variation, E, at the utility level represnted by BB,

$$U(W, M^0), \text{ i.e. } U(W^1, M^0 - E) = U(W^0, M^0).$$

Similarly, for the CC demand curve, the area $W^{0,1}\,{}^1W^1$, is the compensation variation for the CC curve, such that,

$$U(W^1, M^0), \text{ i.e. } U(W^1, M^0) = U(W^0, M^0 + C).$$

It is easy to show that the area under the Marshallian demand curve beneen W^0 and W^1 is $W^0a^1c^1W^1$, and

$$W^0a^1d^1W^1 < W^0a^1c^1W^1 < W^0b^1c^1W^1.$$

For BB parallel to CC, and for AA, BB and CC linear, the conventional consumer surplus is the average of the above defined compensating and equivalent variations.

Another interesting comparison is between the following pairs:

$P^0a^1d^1P^2$ and $W^0a^1d^1W^1$

$P^0e\,c^1P^1$ and $W^0b^1c^1W^1$

$P^0a^1c^1P^1$ and $W^0a^1c^1W^1$.

The paired relations have a common triangular shape (the first is fa^1d^1). Thus, the difference (using the BB income compensated curve) is $OP^0a^1W^0$ minus $OP^2d^1W^1$, which in conventional demand terms is $P^0Q^0 - P^1Q^1$. This difference depends upon the demand elasticity:

$$P^0Q^0 - P^1Q^1 \gtreqless 0 \quad \text{as } \eta \lesseqgtr 1.$$

Hence, the approximation of consumer surplus by the ares under the income compensated demand curve, BB, better approximates the equivalent variation measure of consumer surplus the closer is its elasticity to 1. The CC curve is of about the same elasticity as the BB curve. However, for normal goods the Marshallian curve, AA is definitly more elastic. Thus, the fow- lowing cases are noted; the difference for the Marshallian curve is the same or lower when the elasticity of BB and CC is less than unity while it is higher when the elasticity is above unity. If we assume that the policy maker is interested in the welfare implications of changing the quantity of visibility services (e.g. by improving air quality), he may regard the willingness to pay, defined by the Marshallian consumer surplus, as an approximation to true consumer surplus (compensating or equivalent variation).

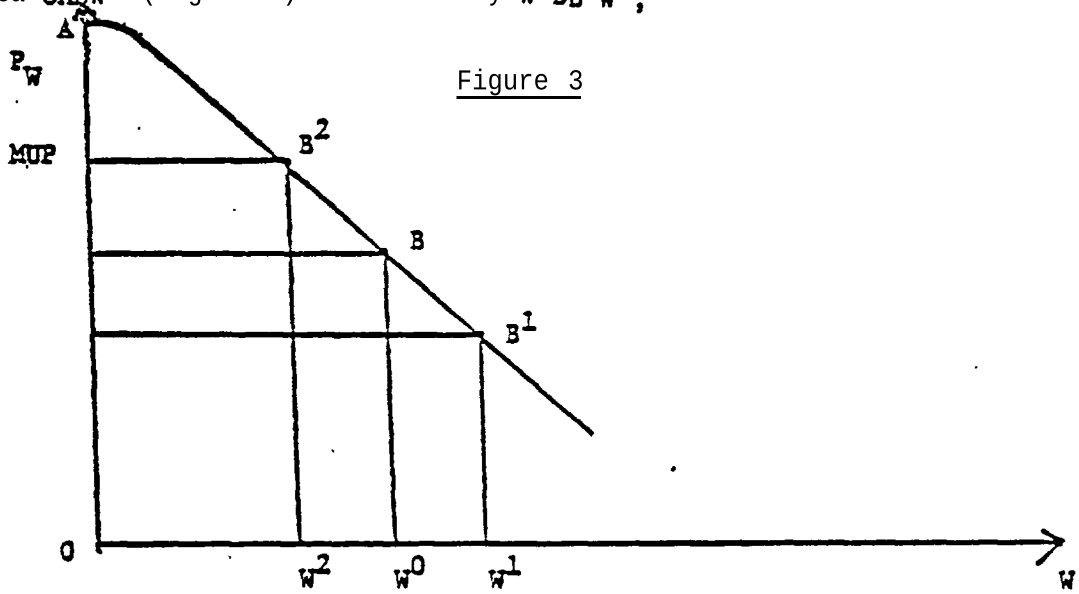
<u>The Demand for Visibility Services</u>

If W is determined exogenously then its marginal product times the marginal utility of the vista's services (MP x MU) is its shadow price. If W is endogenous, its quantity is determined by equating its marginal costs with the product MP x MU, (MUP).

As conventially noted, at equilibrium along the demand for W, the consumer surplus is the rent to the fixed factor - the existing site j. For a given demand for viewing conditions, the lower the marginal cost of visibility services, the more viewing conditions are purchased (e.g. travel until you find the "right" angle to view the rock). The rock's rent, then, is also larger. Hence the point of maximum willingness to pay for visibility, will be determined by the specific site. The maximum sum that a consumer is willing to pay for a particular site is the consumer surplus. The maximum amount the consumer is willing to pay for an additional unit of viewing conditions, W, is its marginal utility value,

If visibility conditions improve from W^0 to W^1 in a given site, the area $OABW^0$ (Figure 3) increases by $W^0BB^1W^1$,

Figure 3



and declines by $W^2B^2BW^0$ when conditions are worsened. The size of area $OABW^0$ is unknown. If one suggests an improvement in visibility from W^0 to W^1, then the amount the consumer is willing to pay for the improved visibility is OAB^1W^1, M^1; if a change from W^0 to W^2 is suggested, the value is OAB^2W^2, M^2. $M^1 - M^2 = W^2B^2B^1W^1 = M^3$. The willingness to pay for visibility conditions at W^0 is approximated by $M^3/2$.

Conclusions

The visibility valuations found in previous studies are biased upward with respect to the marginal value product since they are totals and embody the rents for the various sites that the interviewee is viewing. The experiment that we suggest would subtract out these rents. The willingness to pay experiments, themselves, would not change except that each time an initial W^0 will be chosen explicitly. Willingness to pay is indicated for different changes from the initial W^0. In this manner, the proper $M^3/2$ can be calculated. We expect that $M^3/2$ will decline as W^0 is increased for a given site.

In addition, the difference between valuations for increasing and decreasing W ought to diverge further as the change between visibility levels becomes larger. Large changes, however, might be necessary if the demand is relatively inelastic. Since this is not apriori known, a conclusion of no value might be reached although the consumer's surplus is large (recall the discussion on the relation between the "true" consumer surplus and the one discussed in the previous section).

APPENDIX A

The consumer surplus function is the income compensation function denoted by $M(W|W^0, M^0)$. The function denotes the least income required by the consumer when no more than W units of visibility are available, while he is (promised) to enjoy the same utility level as at W^1, M^0.

Hence,

$$U(W^0, M^0 + C) = U(W^1, M^0)$$

$$U(W^1, M^0 - E) = U(W^0, M^0)$$

where for the compensating variation

$$M^0 + C = M(W^0|W^1, M^0)$$

and for the equivalent variation

$$M^0 - E = M(W^1|W^0, M^0).$$

A.5 ON THE EVALUATION OF THE SOCIAL BENEFITS FROM IMPROVING VISIBILITY

The following paragraphs contain several thoughts on the evaluation of the social benefits from improving visibility. Information on the reaction of the public to improved visibility came in two ways. One was via personal interviews out of which the willingness to pay for improvement were found. The second was the result of analyzing aggregate behavior and participation in specific activities (secondary data).

Analysis of willingness to pay data explains differences in the magnitudes of bids (given the same "objective" improvement in visibility) submitted by different people. The explanatory variables are thus specific to the individual's socio-economic characteristics. Actually in order to find the total value of visibility (improvements) to the population of a certain geographic area the product of the mean bid by the population (or if the bid is per household by the number of households) is a good approximation for it. The parameters of the bid function are needed for a more accurate evaluation, given that either the distribution of the relevant population by the variables that affect the magnitude of the bid is non-symmetric or that the effects of these variables on the magnitude of the bid are non-linear. The two issues of non-symmetric distribution and non-linear effects required ground preparation of sampling a sufficiently large number of observations, a sufficiently wide spread of socio-economic characteristics and well defined representative areas for which the distributions of the population by the various characteristics are known. These requirements have been taken care of in the planning stage.

Analysis of secondary data usually uses environmental variables, including weather and visibility, to explain variation in the participation rate in a certain activity either over time or space or both. Analysis of these data yields the sensitivity of participation or the intensity of the relevant activity to changes in visibility. The following question is how to transform this information into a monetary evaluation of visibility. The present note is aimed at answering this question.

<u>The Evaluation</u>

The analysis of participation in an activity is aimed at explaining observed differences in participation over time i.e., between one day and another. One of the explanatory variables is visibility. If one agrees to the concept of a standard quality unit of the activity and that visibility is one of the components of the vector of characteristics of the quality then, *ceteris paribus,* a change in visibility changes the quality of a unit of activity, which implies a change in the number of standard units per unit of activity. Formally let a standard unit of activity j be defined by $(X_1^o, X_2^o, \ldots, X_n^o)$ where the X^o's are the quantities of each attribute of the standard (for simplicity we disregard the possibility of substitution). Let attribute n be visibility. Thus, if

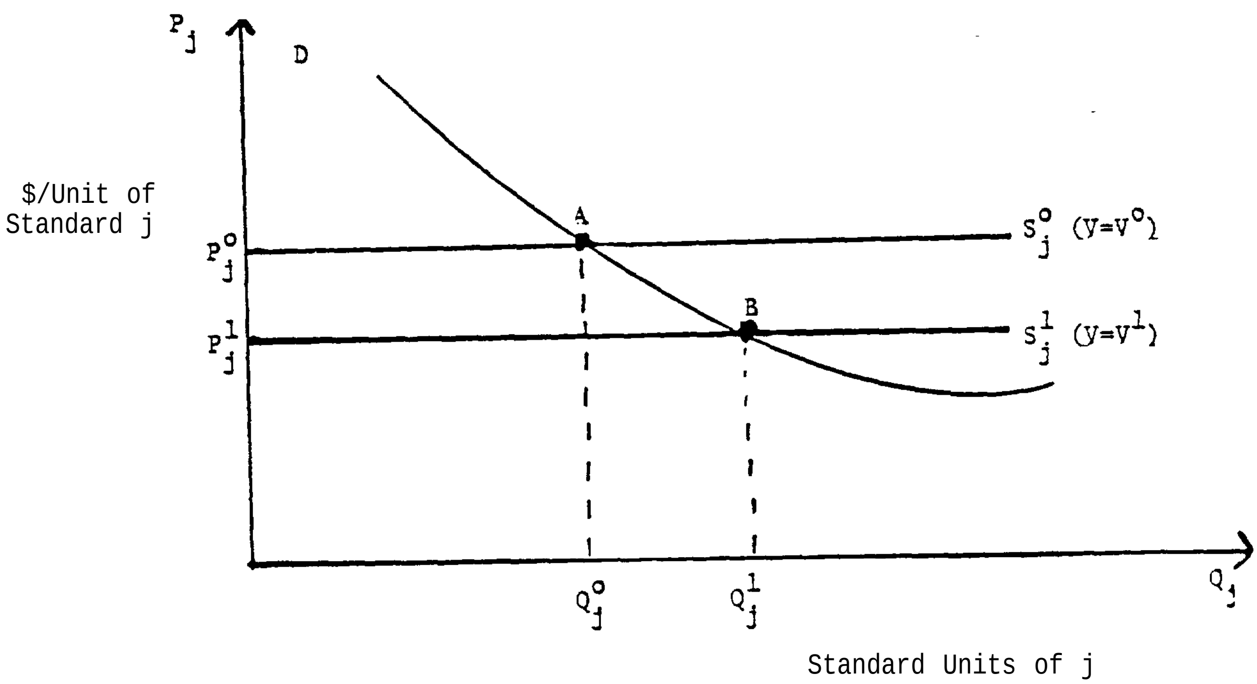
$$\frac{\partial(\text{Quality of activity j})}{\partial X_n} = \beta$$

i.e., the quality denoted by $(X_1^o, X_2^o, \ldots, X_n^o\ X^0 +1)$ is 1+B larger than standard ized quality we interpret it as if it is equivalent to 1+B standard units of activity j.

The use of demand and supply framework to describe different market equilibria requires that the product (service) be homogeneous. Thus, when analysing observed participation in activity j the activity has to be transformed into homogeneous units - each at the quality level of the standard. If we assume that the activities people are involved in are not Giffen goods, then, aggregate demand for each activity is downward sloping in the quantity (of standard units)-price per units of standard quality plane. Furthermore, as long as socio-economic characteristics and population size are constant, demand is stable.

Assuming that visibility is a positive attribute and that the quality - quantity transformation into units of standard quality is at a one to one ratio (as formulated above) then a change in visibility can be viewed as a change in the average cost of supplying standard units of activity j. Hence, if for the relevant range of participation in activity j the average cost of supply is assumed to equal the marginal cost of supply, i.e., they are identical and horizontal in the quantity price plane, an improvement in visibility implies a downward paralled shift of the supply curve (Figure 1).

FIGURE 1



Let the elasticity of demand for activity j be η_j then, due to improved visibility from level V^0 to V^1 if the observed change in consumption of standard units was ΔQ_j the implied decline in cost of production is $\Delta P_j/P_j = \frac{\Delta Q_j/Q_j}{\eta_j}$. The social gains due to the improved visibility equal the area $P_j^0 AB P_j^1$. At this stage two problems are encountered. The first is that the observed Q_j is not in terms of standard units but in units which are unadjusted for quality. Thus, if we use changes in participation rates due to improved visibility as a measure for the change in standarized quality units, ΔQ_j is underestimated and also $\Delta P/P$ is underestimated. Secondly, the average cost of production of a standard unit at different levels of visibility is unknown and likewise the demand elasticity for standarized units is usually unknown. To overcome the second difficulty, studies on the demand for various activities can be consulted. However, none of the estimated elasticities is for a standarized units of activity. Thus, in the following an approximation is suggested. The outcome is obviously an underestimation of the social value of improved visibility. Hence, when defending it, or similarly, advocating public action to improve visibility we are on the safe side.

Let's return to Figure 1. Consider a demand elasticity of unity and regard observed changes in participation rate as changes in quality-adjusted units of activity j. Thus,

$$\Delta P/P = \Delta Q/Q \text{ and } \Delta P = \frac{\Delta Q}{Q} \cdot P,$$

where Q refers to calculated participation at average annual visibility.

One can calculate the value of P when a "regular" (non-standard) unit of activity j is purchased (e.g., value of travel time, automobile costs, parking costs, entrance fee). The social benefits of improving visibility from V^0 to V^1 are approximated by

$$(Q_j^o + Q_j^1)\ \Delta P/2\ .$$

A very conservative value would be just $Q_j^o \cdot \Delta P$, and an inbetween value

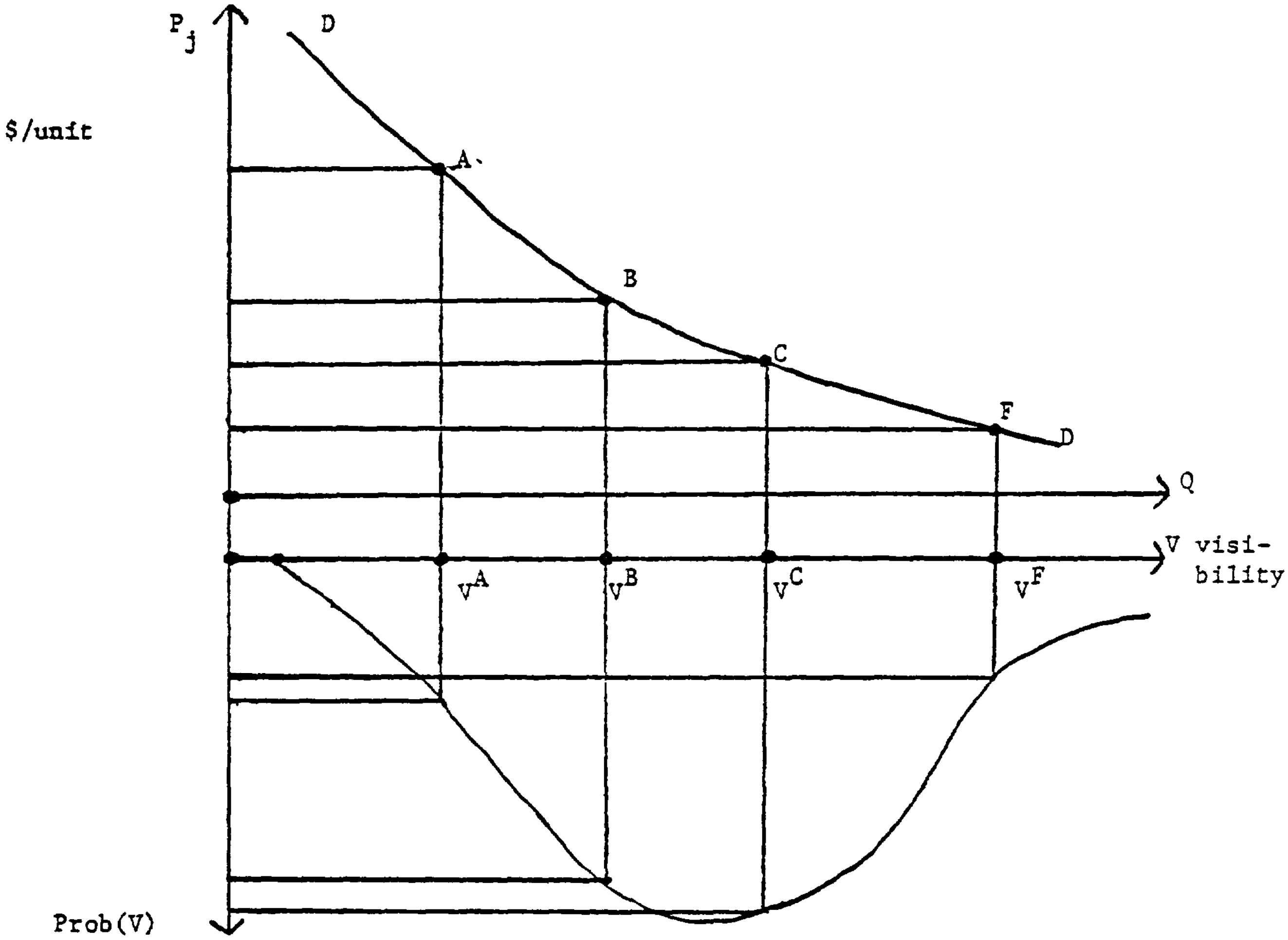
$$(\frac{3}{2}\ Q_j^o + \frac{1}{2}\ Q_j^1)\ \Delta P/2.$$

Note that the values of Q_j^o and Q_j^1 to be used are those calculated from the equation for participation in activity j, i.e., they are the predicted values $(\hat{Q}_j^o, \hat{Q}_j^1)$. Using the variance covariance matrix of the estimated coefficient, the variance of the sum $(\frac{3}{2}\hat{Q}_j^o + \frac{1}{2}\hat{Q}_j^1)$ can be calculated and confidence intervals constracted for measurement of the social benefits.

Generalization

Figure 1 can be augmented by adding to it the distribution of visibility over the relevant period of the year (e.g., for swimming May-Sept.)

FIGURE 2



Define an improvement in visibility as the shift of the distribution of visibility 1 unit (or 1 percent if the analysis of participation was done in a log-log model) to the right. The social benefits due to this improvement are equal to the sum of the areas of type $P_j^o ABP_j^1$ in Figure 1 weighted by the corresponding probability distribution of visibility. In a discrete formulation it is

$$\frac{1}{2}\sum_{i=1}^{m}\left[Q_j(V_i+1)-Q_j(V_i)\right] \cdot \Delta P(Q_j(V_i)) * Prob(V_i),$$

where i denotes a level of visibility (m levels are assumed). Also recall that

$$\sum_{i=1}^{m} Prob(V_i)=1.$$

As an approximation one can assume

$$\Delta P(Q_j(V_i)) = \Delta P(Q_j(V_i')),$$

where ΔP is calculated only once, at the average V.

Summary

The note suggests a common procedure for the evaluation of social benefits due to improved visibility when information on the effects of visibility on behavior is derived from activity participation rates. The method is based on various approximations. This is its weakness but also its advantage. It is relatively easy to apply it to various activities. In addition to the estimation of the participation function only the calculation of average cost per unit of activity is needed. The final outcome is already an aggregate value for the corresponding geographic area for which the participation was measured. We also argue that the various approximations lead to an underestimation of social benefits. Thus, they would not be refuted by more careful and sophisticated estimation-calculation techniques.

A.6 VISIBILITY AND ITS EVALUATION

In the following we discuss the concept of visibility, explain how different persons conceptualize visibility, and attempt to explain why different people bid different amounts of money for what is "objectively" the same change in visibility.

Visibility

The dictionary defines visibility in general terms:

a) The quality or state of being visible
   (the visibility of a navigational light)

b) The degree or extent to which something is visible, as by the clearness of the atmosphere

c) Capability of being readily noticed

d) Capability of being distinguished

e) Capability of affording an unobstructed view

The term visible is defined similarly:

a) capable of being seen
b) perceptible by vision
c) easily seen, impressive to the viewer

The conclusion one can draw from these definitions is that visibility is a subjective property assigned by the human mind via the eyes with or without the usage of visual aids (e.g., binoculars) to various capabilities all of which are related to vision. The capabilities usually emphasized are: the identification of objects at different distances at different levels of clearness, preciseness and brightness, the capability of distinguishing between different objects and between definite colors. With regard to colors a comparison with an "ideal" color takes place where the ideal is a subjective standard the individual has acquired and constructed given past experiences of viewing various objects under various environmental and topographical conditions.

Hence, the declaration that visibility is good or bad, improving or getting worse reflects differences between perceived visibility at a specific site, of a specific object, at a specific time of day and environmental conditions and the ideal visibility one has in mind as the numeraire. We might consider ideal visibility to be a constant for each individual but different for different individuals. Then experimentation with the same individual will yield a set of values all refering to the same base. On the other hand, experimentation with many individuals on one scene yields many values which however, are non-comparable, The reason is that they refer to different bases and different subjective perceptions of the same view by different people. Furthermore, differences between people's "ideals" and differences in subjective perception are not necessarily perfectly correlated, given the host of factors that affect perceived visibility and which affect different people differently. Thus, attempting to adjust for the unknown ideal base by using background socio-economic variables related to individuals does not necessarily transform statements of perceived visibility to a common base. On the top of this is the question whether we know what are the relevant variables that determine the standard of ideal visibility.

Following the various definitions and expectations from visibility it seems reasonable to conclude that visibility is not single dimensioned. It is composed of a set of characteristics or functions it fulfills. Hence,

$$V = [v_1, v_2, \ldots, v_n]$$

where v_i is the level of achievement of the aimed at function i. When an individual is shown a picture or is asked to compare two pictures from their visibility point of view we hypothesize that he is capable of classifying the difference for each i. Now let's experiment with him.

Show the individual a picture and ask him to rank the level of visibility it displays on a scale from 1 to 10. Then ask him to give it the rank he thinks the majority in the society would rank it. This first experiment would indicate whether the questioned individual has any particular attitude towards visibility that is different (and knows about it because of previous experience) from the average in the society. Then show the individual at least three sets of three pictures each and ask him to rank visibility within each set on the 1 to 10 scale. The purpose of this ranking is to quantify the perceived n dimensional vector into a single dimensional vector. (See reservation below.) An interesting test of the hypothesis that each individual has a different perception of visibility would focus on the distribution of the ranks given to the same picture by different individuals. Similar tests for different perceptions could be done on the differences in ranks given to two pictures.

For each set of pictures, following the order they were ranked from top down, ask the individual about his WTP per year in order to avoid deterioration of visibility from that ranked at top to that ranked second and then from that ranked second to that ranked third, and so on. So far, attempts to explain WTP data have employed conventional socio-economic characteristics and variables revealing an individual's attitudes towards the environment, recreation habits and intention to migrate. We hypothesize that the explanation of WTP data would be improved if the analysis also included as variables the absolute difference in the ranks given by the subject to the pictures, the rank given to the "best" picture, and the difference in rank for the picture evaluated by the subject for himself and for society.

To be more explicit we postulate that the absolute difference in ranking affects WTP positively (it quantifies the difference in visibility). The rank given to the "best" picture captures the particular evaluation of the entire set. (If the best already ranks low there is little to expect to be paid for avoiding further deterioration - no use, or, maybe high payment - increasing marginal disutility.). We suggest that the ranking of visibility on a 1 to 10 scale be part of the questionnaire and the ranks be used in explaining the bids.

More on Ranking and Valuation

When the individual is asked to rank visibility on the 1 to 10 scale we actually ask him to apply his personal weights to each of the n attributes in the visibility vector. Hence the rank by individual j is:

$$s_j = \sum_{i=1}^{n} w_{ij} v_{ij} \qquad\qquad s = 1, \ldots, 10.$$

Given the idea of an individual ideal standard

$$v_{ij} = \bar{V}_{ij} - V_{ij}$$

where $\bar{V}_{ij}$ is the ideal, and V_{ij} the perceived. The final rank assigned is thus a weighted average of the difference between the ideal and the perceived. If we could be sure that the individual is consistent with regard to the weights he uses, the experiment suggested above would permit the explanation of WTP for visibility. However we doubt this consistency. In particular it is uncertain whether the w_{ij} are constant for individual j or are a function of the circumstances of the experiment i.e.

$$w_{ijt} = w_{ij}(\mu_t).$$

$w_{ij\,t}$ is the shadow price (value) individual j attaches to attribute i at the circumstances prevailing in t. This leads us into the issue of the determination of shadow prices.

It is commonly accepted that visibility is used as an input in the production of consumer goods i.e., visibility enters into the utility function only indirectly via consumed goods. The representation of visibility as a vector of n attributes implies in the present context that <u>each</u> of the attributes is an input. Thus, there are production processes for which only specific attributes are needed, while others do not affect output - the quantity of the consumed good. In other cases all attributes are employed in production or might be capable of substitution -- one for the other. In general visibility is a free good, but it is indivisible and its quantity predetermined exogeneously. Using our previous terminology, at state t (stands for time and location) the level of the attributes v_i are given, $\bar{v}_{it}$. Since everybody can enjoy the same attributes (they are a free public good) they are not traded and in particular can not be substituted one for the other in the market. The individual takes these given quantities and employs them in the production of the consumed good or service (e.g., watch a boat race on the lake). In the production process other inputs, some which are tradeable, can be employed as substitutes or complements to the visibility attributes or human eye whose characteristics are not good enough (e.g., glasses, binoculars, standing on a high building). For different activities (production of consumable services), different attributes of visibility are needed to a different extent. E.G., if one is watching boats on the lake the distance attribute is most important and next to it the capability of distinguishing among colors. When visiting the Brayce National Park color contrast is more important than the capability to see a long distance. I am using the term important to stand for the economic term MUP = MP * MU -- the marginal utility product. (Recall the similarity to MRP -- marginal revenue product, which is the product of MR and MP.) The units of the marginal utility product are of utility ($MP_{Vi} = \frac{\Delta \text{ units of service } x}{\Delta \text{ unit of attribute of visibility } i}$, $MU_X = \frac{\Delta \text{ units of utility}}{\Delta \text{ unit of } x}$. Hence, $MUP_{Vi} = \frac{\Delta \text{ units of utility}}{\Delta \text{ unit of attribute of visibility } i}$).

In the process of producing service x, more than one attribute of visibility is employed. (It may be that attribute i + 1 improves the quality of x that is produced using attribute i. This change in quality affects utility and thus can be expressed similarly.) Thus, the weights the individual assigns to the various utility attributes when we ask him to evaluate a certain visibility on the 1 to 10 scale are the MUP's that are particular to the view we show him and circumstances at which he sees it. Thus, the same individual will assign different w_i per unit of attribute i under different circumstances.

Furthermore for the presumably same view different people will assign different w_i per unit of v_i simply because their personal production function differs and utility differs; thus their MUP_{vi} differ.

When an individual is asked to rank visibility he calculates the values

$$\sum_{i=1}^{n} w_i^k V_i^k \text{ and } \sum_{i=1}^{n} w_i^1 V_i^1$$

where 1 and k are the same picture at two different levels of visibility. We traditionally assume that

$$w_i^k = w_i^1 \qquad i = 1, . . . , n$$

Thus the difference on a one dimensional scale is

$$\Delta s = \Sigma w_i (V_i^k - V_i^1) = \sum_{i=1}^{n} w_i \Delta V_i$$

Thus when asked about WTP the relation is

$$WTP = f(\Delta S, y)$$

where y is all other variables affecting WTP.

Two different individuals would thus bid differently even if their preceived ΔV_i are the same if their w_i differ. I suggest that by asking the individual to scale various picture on the 1 to 10 scale we get a good approximation for his ΔS and thus our explanation for the WTP would improve. A difficulty arises if $w_i = f_i$(some elements contained in y). This can be checked by relating ΔS (and also the scale he assigned the best picture we showed him) to all the elements we consider to constitute y. (A multiple regression would do this job.).

Conclusions and Preliminary Remarks for the Eastern U.S. Study.

The main argument put forward in the discussion is that visibility is multi-dimensional; that the importance of each dimension depends on the specific scenery; that judgment of changes in visibility depends among other things on the standards people get use to and to what each vector of visibility attributes is compared to.

In order to better understand the WTP declared by people (without currently reflecting or suggesting changes in the various questions in the questionnaires) we have to get a better idea of the quantification of perceived changes in visibility. One simple reason for that need is that declared WTP is a second stage quantification of visibility after applying to differences in attributes weights that are dependent upon the process of producing viewing services and output in the individual's subjective utility function. Without knowing the basic information how could we explain the outcome?

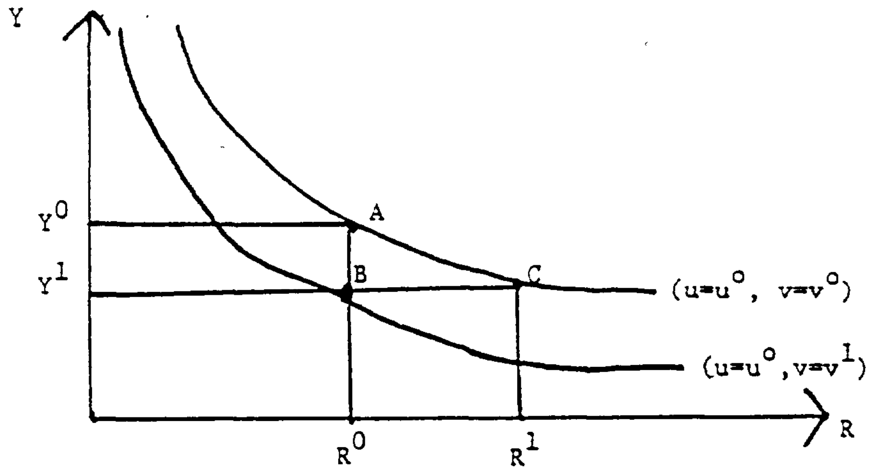
The issues raised above are magnified once the area over which the planned improvement of visibility is widened to the extent that the individuals questioned are not familiar with all available views. The possible extention carried out by individuals can be in either of two directions. The first is a mere extrapolation i.e., given that the extended area is k times the area previously questioned, willingness to pay is k^{α} times the previous payment where $0 \leq \alpha \leq 1$. Another way is more sophisticated and can be expected only from people that are familiar with the area. They attempt to apply specific weights to various scenes and then aggregate over the scenes. Both procedures are probably inadequate, implying that any extrapolation is likely to yield WTP which would be difficult to explain. Thus, the alternative of sampling different people at different locations for different vistas and then aggregating over them seems to be the preferable way.

A.7 VISIBILITY AND OUTDOOR RECREATION ACTIVITIES: A RESEARCH FRAMEWORK

In this study we attempt to outline the value of visibility in outdoor recreation activities. The underlying idea is that there is an alternative cost in addition to the direct cost and that these costs and visibility are the inputs in a production function that provides the consumable commodity - the Becker approach (1965). This approach is compatible with that in which the "production" phase is by-passed and the utility function contains two arguments that are related to the recreation activity: a quantity measure which is a function of the cost and a quality measure which is a function of visibility. The two are substitutes in the sense that one can compensate for the other along an indifference curve. Yet we emphasis the assumed assistance in increasing utility by letting the second cross derivative of the utility function be positive. This second approach is in line with Maler (1974), but is somewhat more general since it does not necessarily require the quantity of the recreation activity to take either of the two values 0, 1.

Visibility Value One Activity

Assume that the expenditure on the recreation activity, R, is variable and positively related to the quantity of services obtained (seat in the stadium, length of stay on the tennis court or golf course). There is another consumption good which we refer to as income. Visibility affects only the utility from the recreation activity. Visibility does not have an explicit market price and it is a public good. If we could have a three dimensional space, an indifference curve map would represent the tradeoffs between income, quantity of recreation and quality of recreation. We use a two dimensional space. Thus over each indifference curve both the level of visibility and of utility are constant. Individuals' total income is Y.



The observed relationships are

$$u(\bar{Y} - R^o,\ R^o,\ V^o) = u(Y^o - R^o - \Delta Y^o,\ R^o,\ V^1)$$

or

$$u(\bar{Y} - R^o,\ R^o+\Delta R^o,\ V^o) = u(\bar{Y} - R^o, R^o, V^1)$$

Hence ΔY^o is the compensating variation - while ΔR^o is the equivalent variation. Also both ΔY^o and ΔR^o might vary with $\bar{Y}, R^o$ and $V^o (V^1 = V^o + \Delta V, \Delta V =$ Constant.) Similarly $MRS_{y/r}$ at A is not necessarily equal to that at B. They are equal if MU_y is independent of visibility $(R=R^0)$. The assumption that XU_R is independent of visibility is more difficult to grasp. One would expect it to increase with visibility. Hence given that the $MRS_{y/r}$ is MU_R/MU_Y one would expect $MRS^{(B)} > MRS^{(C)}$.

Empirical Implications

The purpose of the study is to get a quantitative measure of the values of ΔY and ΔR. If the two are obtained independently and one might expect the corresponding MRS to be aobut 1.0 (both are measured in dollars) then a check for consistency is at hand. Yet before approaching this task one should be aware of the fact that there are several recreation activities and they may be close substitutes. The individual behaves such that his utility from the allocation of the budget (full income) is maximized. Hence under unfavorable visibility conditions that affect the derived utility from a dollar spent on activity A by more than the utility of a dollar spent on activity B we might observe a corner solution with respect to A. This is more likely to happen if the cost per activity is of the form of a two-part tariff (fixed plus variable). Hence the "market" observations on the effect of visibility take two forms. One is the number of participants, the second is the intensity of participation. The situation is confounded if we realize that due to the time consuming input that each activity requires, participation is feasible in only one out of the set of available activities. Usually the length of time needed for consumption is disregarded in empirical demand analysis. Becker (1965) emphasizes its economic role by generating the full price, full income concepts. However the physical limit of time - two activities cannot be performed simultaneously-does not bear its importance in the Becker analysis. For an individual, this constraint leads to a bang-bang solution (either A or B). For the aggregate we expect to get different distributions of participates by activity for different visibilities given that the "reservation" visibilities differ for different persons.

For empirical investigation we collected data on one outdoor spectator activity - baseball - and one participating outdoor activity - swimming. For each activity the data needed were the attendance rates and the distribution of attendance by length or intensity. The intensity variable can be proxied by the quality of seat, which is positively related to the ticket price. Hence, following the model presented in the first section, one expects that the worse the visibility the better is the purchased seat. Yet several difficulties must be realized.

a) Seats are sold in advance. Thus the purchase is done under uncertainty with respect to the visibility at the day of the game. The larger the variance of visibility the higher the mean of the quality of seats sold. Given the seasonality of each of the games, unless cross-sections-over-cities data are collected the variance effect is undetected.

b) The individual decision making model does not account for externalities. In the framework of our discussion these will be reflected in congestion and by "all seats of quality 9 are sold" which are due to capacity limits of spectators recreation locations. Thus, if capacity is reached the distribution by quality of seats is invariant to visibility.

c) For spectator activities the demand for attendance and the distribution of seats are not independent from the competing teams. While one of the teams is always the home team the other team varies. Data for more than one season are needed in order to estimate an unbiased effect of visibilities on attendance and seat distribution.

The data referred to above are the "macro" data. In order to estimate the effects of the socio-economic characteristics of the population on the corresponding compensating variations and equivalent variation "micro" data are needed. At this stage, we do not discuss the specific contingent valuation instrument but would like to raise one point: the ex ante vs. the ex post values. Ex ante refers to before the game and thus before the actual effect of visibility on the utility derived from the game is observed. Ex post refers to the after-observing-and-experiencing effect of visibility. In the ex post case more information is available and thus the $\Delta\hat{Y}$, $\Delta\hat{R}$ are better representatives of the CV and EV. Yet the whole experiment of valuing visibility has an ex ante nature.

A.8 THE DEMAND FOR VISIBILITY SERVICES

In this section we measure the economic value of an aesthetic characteristic of the environment as revealed through the demand for a private and priced service. Specifically, we estimate a site specific valuation of visual air quality by estimating the demand for access to views at a major observation deck in Chicago. Unlike alternative methods for the Valuation of environmental services, the method examined requires no extensive primary data collection. Day to day variation in vistation and visibility permit an estimate of aggregate demand.

The salient unorthodox feature of the demand analysis is that neither an explicit price of the service, nor income nor wealth of the demanders are explicit variables in the model. For the price of the service we substitute a variable that is presumed to be perfectly correlated with the true price variable. Because the time period examined is so brief, income can be assumed to remain constant. While the outcome is but partial valuation of visibility, we suggest that such analyses of observed behavior offer important corroboration to values derived through less conventional methods.

The Demand for Visibility

The purpose of this section is to describe the quantitative response at the observation deck to changes in visibility conditions. We thus defer theoretical considerations of utility and indirect utility functions which are a usual starting point for demand analysis. Instead, we specify the general aggregate demand function for that activity as a function of its price, income and the prices of substitutes and complements:

$$(1) \qquad q = f(P_d, I, P_1, \ldots, P_n)$$

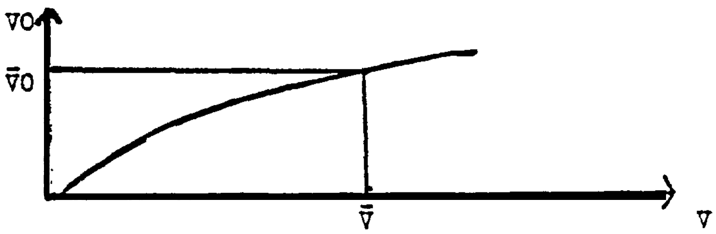
Insofar as q measures a quantity - visitation in a given time period -- the variables specified in (1) are defined somewhat differently from those in a conventional, demand study. Also on theoretical grounds, it is possible to find better definitions than the ones used here. However, the empirical orientation of the analysis leads to practical and observable definitions. For example, a more precise quantity variable would be the number of man hours per day spent observing. Correspondingly, an ideal price measure would be marginal cost per unit of time spent viewing, including relevant direct and indirect costs. Unfortunately, however, these two measures are not available. Instead, the quantity variable is represented by the number of people participating in viewing while the price variable is assumed to be the sum of all costs divided by the quantity of visibility services. These total costs are assumed to be constant across all users. The quantity of visibility services is the pivotal point of the theoretical model developed below.

For reasons of simplicity, assume that viewing from the tower observatory is in all directions and that the density of vistas is equal per unit of area regardless of the distance from the tower. A major input for producing visible objects is the visual air quality. This input can be measured by different dimensions, all of which are convertible to "distance of visibility." Eyes, too, are a necessary element in the viewing process. The natural characteristic of eyes are such that the further away is the object on which the eye focuses, the less clear is that object. Hence, adjusting the quantity of objects viewed by the quality of the view (similar to a discounting procedure except in this case with respect to distance) yields a measure of standardized visible objects, denoted VO, where,

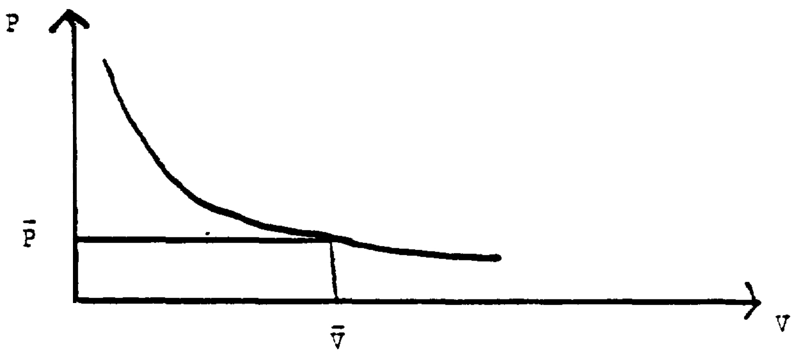
$$VO = \int_0^{\bar{V}} 2\pi YRe^{-\rho R} = \frac{\pi\rho^{2}}{2}\left[1-e^{-\rho\bar{V}}(\bar{V}\rho+1)\right]$$

where $\bar{V}$ represents the viewing distance allowed by air quality. Clearly,

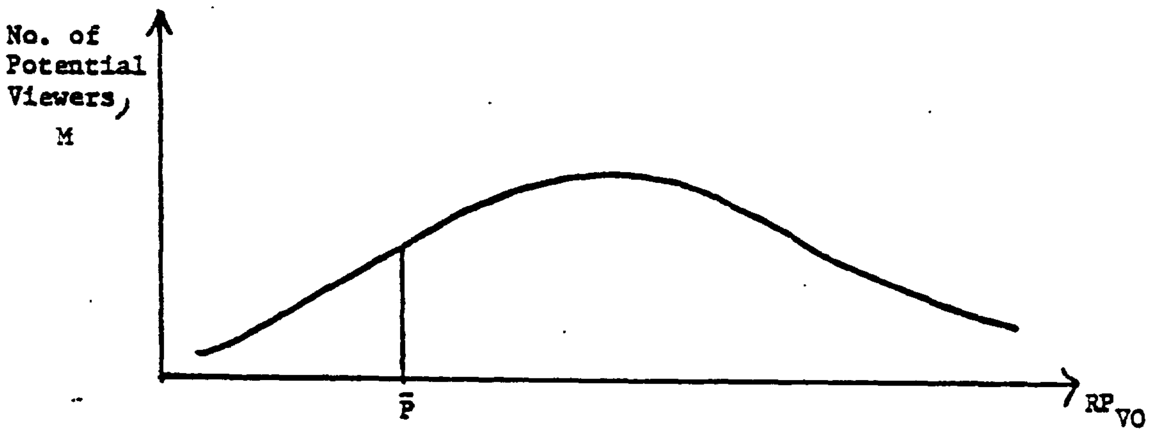
$$\partial VO/\partial\bar{V} > 0 \quad \text{and} \quad \partial^2 VO/\partial\bar{V}^2 < 0.$$



The sum of the entrance price charged by the observatory tower, the value of traveling time, and travel costs is assumed independent of visibility and is denoted TP hence, the average per unit of view is p = TP/VO, which is negatively related to VO. Given the above relation between VO and V, the figure below relates P to V.



We now rank the potential customers of viewing services by their reservation price per unit viewed. If this distribution is stable, then the lower the price per unit of view, the greater the number of people whose reservation price would exceed the actual price. Hence, visitation would rise and more would consume the services of the observation tower. $\bar{M}$ is the measure of the quantity demanded the number of visitors per unit of time.



Hence,

$$\bar{M} = \int_{\bar{P}}^{\infty} M(P)\,dP, \quad \text{such that} \quad \partial\bar{M}/\partial\bar{P} < 0.$$

The remaining elements in the demand function are the prices of substitures and complementary goods which are not built into the reservation price. Substitutes as a group would be comprised of all other recreational activities. We argue here that either the prices of alternative activities are constant over the analyzed period, i.e. are unaffected by changes in visual air quality, as for example, museums; or that changes in visibility affect their effective prices to a lesser extent than they affect the effective price of the services rendered by an observation tower. (This is another difficulty with valuing visibility in an urban setting compared to a National Park where only visual air quality at the time of visitation may be important.) Obviously, it is less costly to postpone or forego a trip than changing or canceling plans for activities that are highly time Intensive. Effective competition comes only from other towers in the area.

Assuming that increments in visibility affects V0 uniformly, the relative price between towers for visibility services is independent of the level of visibility. This implies a constant distribution of the consumers of observation tower services over the various observation towers. Hence, changes in visibility conditions leads to equi-proportional changes in the demand for each of their services.

Model, Data and Results[1]

The basic model that has emerged from the previous section relates the number of visitors per unit time to air visual quality at the time. In order to get this "net" relation, the gross figures of visitation have to be adjusted for other variables that determine or cause variation in visitation. These variables include day of the week, season of the year, special events, holidays, and meteorological conditions other than visual air quality. The unit of time for which the participation rate is explained is: once a morning; once an afternoon; and once the entire day (which in some sense accounts for substitution among activities during the day),

Substitution over time may take another form - that of substitution

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[1]We are grateful to the management of the John Hancock Tower for providing us with the visitation rate by day for the last year and a half. For unknown reasons, the management of Sears Tower refused to provide us with comparable data.

between visiting days. This for of substitution is particularly likely to be found among visitors to the area. Normally, visitors plan to consume a bundle of services over their period of stay in Chicago. The exact timing of consumption of a particular service does not change the utility derived from the entire bundle nor from any particular service. Thus, not only will there be substitution between periods in a day, but also between days themselves. This implies that a relatively high demand might be observed in spite of poor visual air quality, if this day is the second or third in a row of poor visibility conditions. Along this line of reasoning, we see that consumers may indeed hasten their consumption of observatory services on days when air quality is high because of uncertainty about the quality of visibility over the next day or two.

These substitution effects, both forced and planned, obscure the interpretation of the coefficient of visibility in the demand relationship from the point of view of the calculation of the social costs of low visibility in an urban area.

The estimated model is that of a linear least squares regression, where specific attention is paid to its the series nature. The model is

Model 1: $Y_t = X + X_t\beta + z_t\gamma + \varepsilon$

Yodel 2: $Y_t = X_t^{\beta} e^{(\alpha + Z_t\gamma + \varepsilon)}$

Y_t = number of visits to Hancock Tower on visit day t, t=1,...,N

A visit day may be defined in the following ways:

Y_{t1} = number of visits in A.M. hours

Y_{t2} = number of visits in P.M. hours

Y_{t3} = number of adult tickets sold during A.M. and P.M. periods combined

Y_{t4} = number of student tickets sold during day t

Y_{t5} = total number of visits by all groups during day t

Explanatory Variables:

X_{ti1} = visibility services during time period t_i

Visibility services will take either one of two alternative measures. The first will be simply visual range at the Tower. The second will be defined as the area of a circle determined with visual range as the radius discounted by the R^2 maximizing rate. That is,

X_{ti11} = V in miles

$$X_{ti12} = \frac{\pi}{2\rho^2}\left[1 - e^{-pv}(pv+1)\right]$$

(in log form the $\frac{\pi}{2\rho^2}$ will be dropped)

In addition, two lagged visibility variables will be included; the first wi11 be the appropriate V from the previous period and the second from two periods earlier.

Finally not introduced

Price of substitute

$x_{ti2} = P_I/P_e$ where P_I is a price index and P_e is the price of admission to the observation deck

$x_{ti3} =$,t=1,...,N = a time trend variable.

X_{ti4} = tourists in Chicago (conventions)

Z_{ti1} = percent of sky covered at 9:00 AM.

Z_{ti2} = rain (a zero/one-dummy variable)

Z_{ti3} = cloud cover height in feet.

Z_{ti4} = Temperature in degree Celsius (This effect might be non-linear)

Z_{ti5} = a day of week dummy, either weekday/weekend or a dummy for each day of week.

Z_{ti6} = holiday/ non-holiday, dummy variables

Z_{ti7} = month or season, dummy variable. Eleven dummies or 3 for groups:

1) Dec., Jan., Feb.
2) Mar., April, May
3) June, July, August

Z_{t18} = special events dummy variable.

As described above, the model can be estimated in both levels and on a log-log transformation where the estimated coefficients can be interpreted directly as elasticities. The VO variable is entered as $^{1}/_{VO}$ and the coefficient is invariant with regard to fixed costs and total costs TP. Hence the true coefficient is $\beta' = (\beta)(TP)$, where β is the estimated coefficient. In the log-log regression, TP can be disregarded as well as $\pi/2_p^2$ (they become part of the constant). The estimated coefficient can be, however, interpreted directly as the elasticity of visitation with regard to price.

Current atmospheric conditions may affect visitation due to changes in visibility or through more direct effects on the costs or comforts and safety of urban travel. Past atmospheric conditions may alter current visitation through effects such as snow and ice accumulations. The degree of cloudiness or sunshine may also effect the pleasantness or unpleasantness of outdoor travel or recreation.

On first trial all the mentioned atmospheric variables were introduced into the estimated equation. Given that both visibility and atmospheric conditions are introduced with lagged values, multicollinearity is likely to show up. If one uses the rule of thumb definition of multicollinearity, that is, "correlation among the independent variable," then it is very possibly present in our study as such responsible for the relatively high standard errors of estimated coefficients.

As is apparent, the variable of greatest interest is visibility services, VO. Denoting the coefficients of X_{1it}, X_{1it-1}, X_{1it-2}, by β_o, β_1, and β_2, a program that stabilized visibility at a steady state implies elasticity of visibility with respect to visitation of β_o, β_1, β_2.

Deducing the Value of Visibility

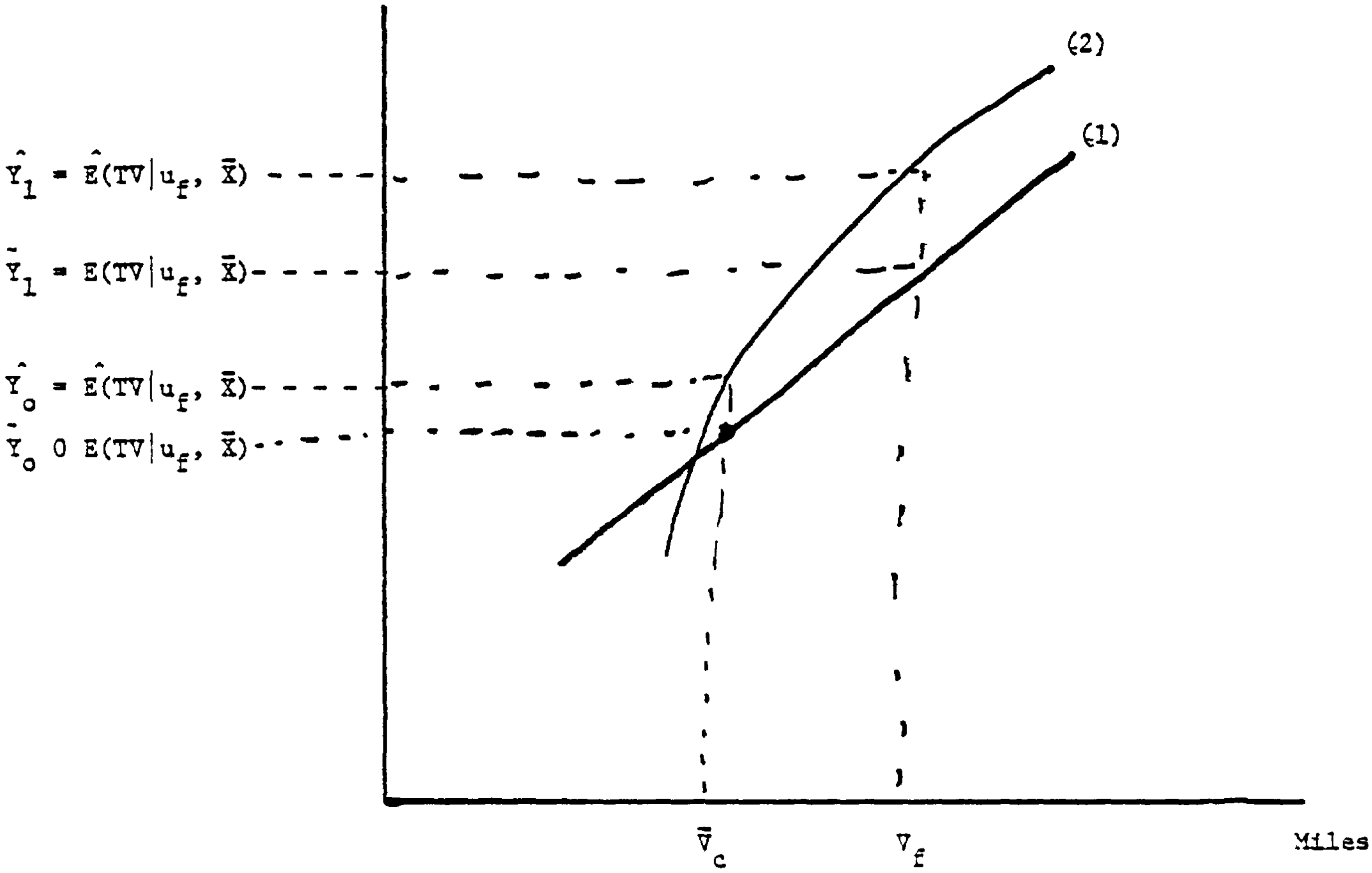
The models estimated above quantify the response of visitation with regard to visibility services and other independent variables. Evaluating the visitation response equations in the admission price/total visitation plane, one can examine the demand for admission to the Tower.

Visibility services resemble a pure public good where consumption by one individual leaves unaffected the amount of service remaining for the consumption by another. Hence, to value visibility services, a total value equation is of interest.

The total value equation is estimated by evaluating the visitation response equation at mean values of independent variables and then multiplying the result by the Tower admission price (Figure 1). Total value curve (1) results from evaluating estimated equation (1) at various levels of visibility and mean values of other independent variables. Total value curve (2) results from evaluating estimated response curve (2) in the same manner. As shown in Figure 1, the non-linear total value relation yeilds a slightly higher value of Tower services at current visibility level V_C. To estimate the daily value of a change in visibility services at the Tower, one need simply calculate the change in total value. For example, if policy

Figure 1

Visibility and the Value of Visitation



is presumed to shift typical visibility from V_c to V_f, then the value of this shift in terms of services at the Tower would be $\hat{Y}_1$ - $\hat{Y}_0$ in the case of the non-linear total value curve or $\hat{Y}_1 - \hat{Y}_0$ in the case of the linear total value curve.

In terms of a total valuation of a policy change, present value estimates are biased downward. First and perhaps most obviously, the present value estimates are site specific and only consider the change in value due to services viewed from a single site. To approximate a site valuation total, a study would identify all important sites within the area affected by policy and then total the effects of a policy induced change over all sites.

A second important reason for undervaluation conceptual. As visibility rises, an individual's reservation price is also likely to rise. However, admission price does not change and individual's already viewing Tower services at the initial level of visibility would realize an unmeasured gain in utility. In Figure 2, this gain is demonstrated. At visibility level V_c and income level Z_0, an individual realizes a utility level u_1 by paying price p_e and visiting the Tower. However, if visibility rises to V_f, the same individual by paying the same price p_e can realize a utility level u_2. Given an initial situation (Z_o, p_e), the individual would be willing to pay up to \$8.00 to realize this gain. Hence, the estimated total value functions overlook 6 for each individual who would pay p_e at visibility level V_c and estimate only the value due to additional patronage. For either increments or decrements in visibility from $\bar{\bar{V}}$, then, the total value curves will tend to underestimate willingness to pay.

A third reason the valuation of visibility may be downwardly biased is due to the definition of the dependent variable. As simply the aggregate visits to the Tower, the dependent variable does not account for variations in the amount of time an individual may spend at the Tower. If each individual spends the same amount of time at the Tower regardless of visibility then obviously this specification error is not a problem. However, if time spent at the observation is positively related to visibility, then by disregarding this relation, the total value specified as above may tend to underestimate the effect of visibility.

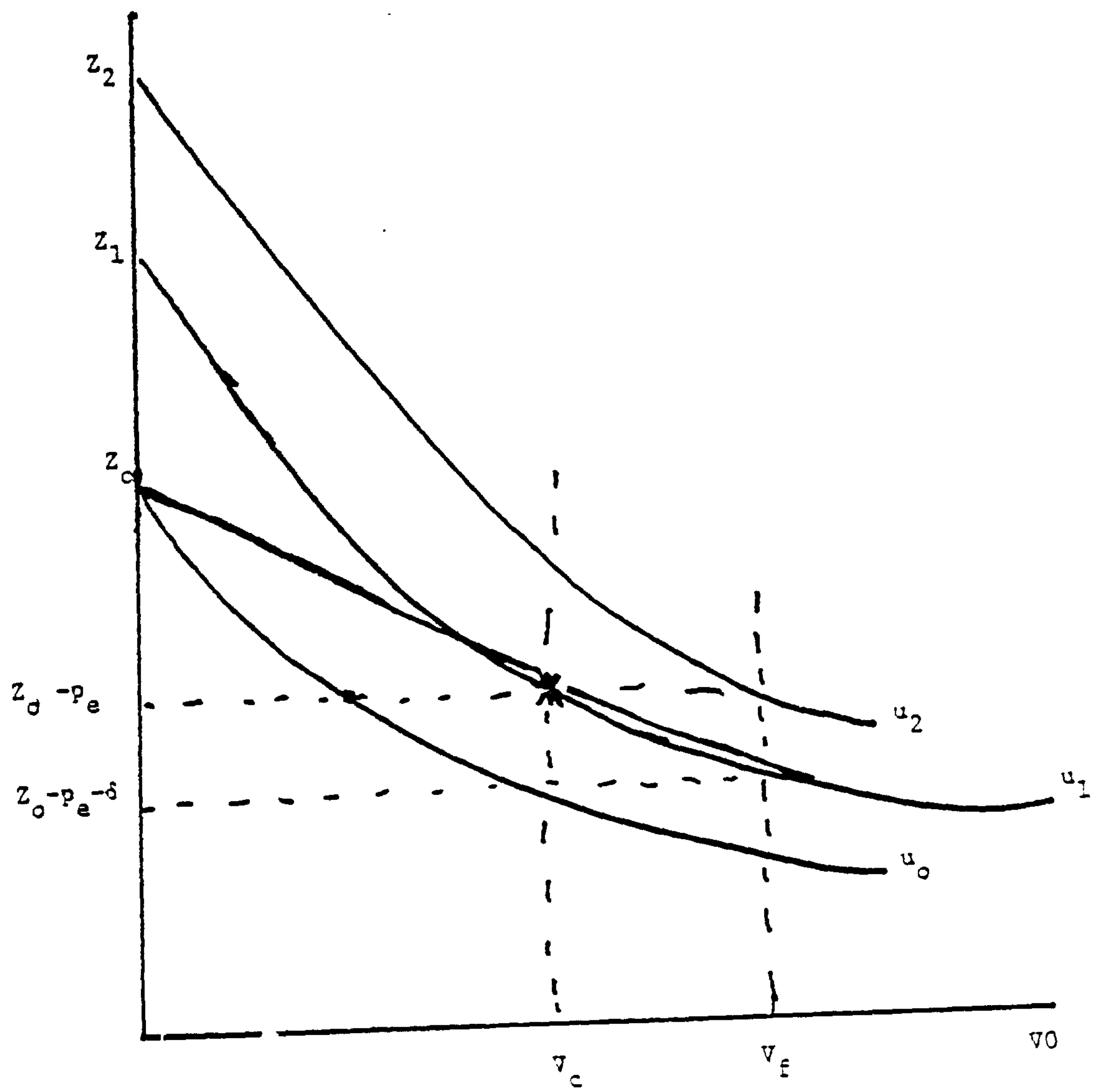
Depending on the precise relation between visibility and time spent viewing, the effect on the valuation procedure may be minimal. For example, let price be defined as a function of time spent viewing. Specifically, let the relevant price be the price per unit of time spent viewing and let this price therefore be calculated as total costs including opportunity costs divided by the time spent viewing at the Tower. Given that time spent viewing at the Tower is presumed to be increasing, then we might assign the following relation:

$$h = h_o V^{\alpha}$$

where h is time spent viewing, h_0 is some minimum input of time, and V is visibility. Then the price of viewing per unit of viewing time is:

$$\begin{aligned} p &= \frac{wh + \bar{c}}{h} \\ &= w + \frac{\bar{c}}{h} \\ &= w + \frac{\bar{c}}{h_o} V^{-\alpha} \end{aligned}$$

FIGURE 2



If another leisure activity and not work is the alternative to visiting the observation deck, then w equals zero and the coefficient of V in the estimated equation (1) is an estimate of α. In so far as the functional form chosen for f(V) seems general enough as an approximation, estimates of total value with respect to V do not seem to be seriously affected by the present specification of dependent variables.

A.9 THE EFFECTS OF VISIBILITY ON AVIATION IN CHICAGO

Visibility affects the flow of air traffic in many ways. First, if visibility falls below 1 mile, all traffice must be under Instrument Flight Rules (IFR). This stops some general aviation activity for both flight training or recreation. Depending on the aircrafts equipment and landing systems at certain airports, operations may be legally continued down to 200 yards of visibility.

Another effect of lowered visibility is the delay of take-offs (TO) and landings. At low 1evels of visibility, a spacing of at least 1 mile must be maintained between aircraft. This greater spacing reduces the numbers of TO and landings that can be made. For instance, suppose that greater spacing delays each aircraft by one minute at O'Hare International Airport. Assuming that approximately 60 take-off's and landings are handled per peak hour of traffic, total operations are delayed overall by one hour.

Decreased visibility can also lead to accidents or near-misses by contributing to either pilot or air controller error. Lowered visibility can cause incoming flights to divert to other destinations causing delays to those on board and imposing additional aviation and ground transportation costs.

Economic Modeling

The object of this section is to provide a framework for valuing visibility. First consider the effects of visibility on TO or landing operations at a given airport. For commercial air carriers the effect of visibility on the actual number of flights is expected to be quite low. This is because they generally operate at the best equipped airports and with the most sophisticated equipment. The effects of diminished visibility on general aviation are not so clear. First, when the visibility falls below 1 mile, all VFR flights stop. Prospective flyers must then decide whether they wish to fly IFR or postpone their trip. If IFR is chosen, pilots must be IFR rated and have properly equipped aircraft. Given these observations, it is an a priori expectation that lowered visibility would decrease the number of flights. However, this a priori notion may be obviated by the fact that flights is may not be cancelled but merely postponed until the visibility increases. Weather forecasts are available to pilots from which they can make decisions on postponement or cancellation. If early morning visibility is expected to improve within a short time, departure may only be delayed within a day and hence within the period of observation.

The flexibility of departure tine form the basis for an intertemporal optimization-of-utility model. The pilot/traveler decides when to leave given visibility, general weather conditions and expectations of future weather in order to maximize utility gained from the trip. By the nature of the intertemporal trade-off the value of a trip declines as it is put off, but the increased visibility gained by waiting may add more present value than the cost of waiting. Consider the folowing intertemporal choice model under perfect foresight:

Choose t so as to maximize

$$U(\underline{Z}(t),X(t)\,|V_t,V_{t+1},\ldots,V_N,\underline{W}_t,\ldots,\underline{W}_N).$$

U is utility which is a function of the trip X, which varies in value over t (hence X(t)). $\underline{Z}_t$ is a vector of quantities of other goods. V_t,

$V_{t+1}, \ldots, V_N$ are the known future visibility values and $\underline{W}_i$ is a vector of weather related factors other than visibility. Now, consider the function

$$\left\{X(t) \mid V_t, V_{t+1}, \ldots, V_N, \underline{W}_t, \underline{W}_{t+1}, \ldots, \underline{W}_N\right\} .$$

The value of $X(t_0)$ is 1 when t_0 is optimal, where optimal is defined by weighting the discounted values of $(V_i, \underline{W}_i)$. X_t is 0 for $t \neq t_0$. From this, a demand system can be derived.

Another model of visibility's effect on air travel considers the time delay caused by restricted visibility. As visibility is reduced, the space between aircraft must be increased, creating time delays. This line Of attack could allow a dollar value to be placed on visibility effects. Consider the following technical relationship:

$$TD_t = G(\psi(L)V_t, \underline{\delta}(L)\underline{W}_t, \varphi(L)\underline{O}_t) .$$

Time Delay (TD) is a function of some lag function $(\psi(L))$ of visibility, a lag function of weather $(\underline{W}_t)$ and a lag function of some other factors such as mechanical breakdowns. The lag functions are included because these delays accumulate over time. From this equation, $\frac{\partial G}{\partial V}$ shows the effect of a marginal visibility change on the time delay. By making some assumptions on the value of passengers, a lower bound cost of visibility changes can be calculated.

<u>Empirical Modeling</u>

Consider estimating the first conceptual model of the effect of visibility on the number of flights. The currently available data consist of counts, the total number of takeoffs and landings by day at six local airports by class of aircraft. Weather data are also available. The equation to be estimated is

$$(1) \quad \log C_t = \underline{\gamma}\,\underline{D} + \alpha \operatorname{Log} V_t + \delta \operatorname{Log} H_t + \delta\, P_t + \varepsilon_t .$$

C_t is the count of total take-offs and landings at O'Hare. This variable's meaning is somewhat ambiguous. First, it cannot he determined how many aircraft left and returned on the same day, so the number of take-offs cannot be distinguished from landings. Another even more important problem is involved with determining the degree of intertemporal trade-offs. Since the data are for a twenty-four hour period, we cannot determine if decisions to depart were put off for periods less than twenty-four hours due to weather expectations. That is, after adjusting for seasonal and day of week effects, there may be little variation in counts attributable to visibility because all put off effects are very short run,

The vector $\underline{D}$ is a set of dummies to capture day of week effects. After viewing the data, differencing may be necessary to filter seasonal effects. V_t is visibility on day t and H_t is cloud height on day t, and P_t is a 0-1 variable for whether or not precipitation was present.

From this specification, $\hat{\alpha}$ is the estimated percentage change in counts for a one percent change in visibility. In order to place a dollar value on this effect, the average one hour rental fee in Chicago, for a Cessna 310, a small twin engine aircraft, may used. A lower bound estimate for the daily cost of a one percent decrease in visibility is $\hat{\alpha}$ multiplied by the average count per day multiplied by the average aircraft cost. This represents the average cost of increased visibility to someone planning to take a trip and cancelling or postponing. Clearly, this represents a lower bound for the actual cost incurred.

The other method of deriving a value on visibility uses time delay data. By estimating the technical relationship,

$$\mathrm{Log}(TD_t) = \underline{\gamma D} + \psi(L)\log V_t + \delta(L)\log H_t + \varepsilon\, P_t + D_t,$$

the relationship between V_t and TD_t can be found. Again, $\hat{\psi}$ is the percentage change in TD induced by a one percent change in V, Two pieces of data are now needed. First, the mean number of passengers effected by a time delay and, the value of each passenger's time. By assuming reasonable values for these two factors a lower bound for the cost of time delays due to decreased visibility can be estimated.

Another method of deriving the value of visibility deals with the idea of diverted flights. As was previously mentioned, if flights are diverted due to low visibility, the aircraft passengers have a cost imposed on them. Also, the original destination loses revenue from landing fees, hanger and fuel charges and, the city of destination loses the revenue the passengers would have spent. One way to derive this cost is to look at flight plans filed with the FAA. The number of diverted flights due to low visibility can he found, as well as the number of flights diverting to Chicago due to low visibility elsewhere. This can also be done for flights going to different Chicago airports. If Meigs is socked in by low visibility then incoming flights may divert to Midway, which means that Midway then benefits from Meig's loss. The problem with this analysis is mostly in the expense of gathering data.

At this point, it seems relevant to discuss, relationships across airports. Each airport has a different schedule of landing fee rates. There are also non-pecuniary costs differences across airports due to varying congestion levels. Each airport offers a different bundle of services. There are two major services to be considered. First consider an airport's location to be an input to producing final services; i.e., that of getting the passengers to their final destination. An airport will be chosen so as to minimize transportation costs from the passenger's point of origin to their final destination. A second service or set of services acts as a constraint to this decision. This constraint is in the form of having a runway long enough for the aircraft chosen and the proper landing system given the prevailing weather.

In choosing which airport to fly into, the passenger or pilot chooses that which is most easily accessible to the final destination given that it can be used in the current weather. If Meigs is closed, the flight may divert to Midway. When viewed in this manner, at least for general aviation, the substitutability of airports is evident, as is the fact that the degree of substitutability is a function of the current weather. The third factor in determining the degree of substitutability is of course the prevailing landing rate structure.

A similar route selection decision may be made by passengers of scheduled air carriers. Clearly, for non-pilots and those who do not own aircrafts, the least cost alternative is usually a scheduled commercial flight. However, if time cost savings are substantial, the possibility of aircraft charter enchance the range of substititability. Such charter and nonscheduled flights may be particularly important at Meigs Field near down-town Chicago. However, at other airports and/or most commercial passengers, the cost of charter is likely to outweigh time savings.

Extensions

This section suggests how to extend analysis in ways which add precision to the estimates for visibility costs in aviation. First, consider the model for counts. As weather data for each airport location are collected, six separate equations can be developed in the form of (1). Estimating the six equations jointly adds information to the estimation procedure. The method of seemingly unrelated regression provides a straightforward way to proceed. Consider the following equation system

$$\log C_{i,t} = \underline{\gamma}_i \underline{D}_i + \alpha_i \log V_{it} + \delta_i \log \underline{W}_{it} + \underline{\varepsilon}_t \qquad \begin{array}{l} t=1,\ldots,N \\ i=1,\ldots,6 \end{array}$$

This gives us six α_i's, one for each airport, each of which is estimated more precisely than in the six regressions run separately. So, a lower bound cost can be estimated for each airport and these costs can be aggregated to derive a lower bound visibility value for the entire area.

The other extension applies to the time delay model. Again, the residuals from the six separate regressions are correlated. By applying the seemingly unrelated regression procedure to that system of equations, a more precise time delay elasticity of visibility is estimated for each airport, and as before, more precise estimates of the cost of visibility are made.

A.10 VIEW PRIMARY RECREATION, THE HANCOCK TOWER

An urban resident or visitor is presented with a large number of opportunities to view the urban landscape and skyline. A great many of these viewing opportunities carry a price insofar as one must gain access to a private viewing site to enjoy a special vista. However, in very few of these situations is view-use recorded. For several reasons, urban observation points such as Hancock Tower offered an unusual opportunity to determine the effects of visibility on the demand for viewing services. First, the panoramic view offered by the Tower is particularly sensitive to changes in either visual range or color contrast. Second, an explicit price is charged for access. Finally attendance is recorded on a daily basis.

Various quarterly reports have described intital findings regarding the behavioral and revenue effects of visibility at Hancock Tower. Behavioral equations were refined and progress was made toward a site-specific valuation of visibility. This section provides an overview of the valuation strategy and presents some demand estimates for Hancock Tower services as a function of admission price, visibility and a set of additional demand shifters.

Unlike the common demand analysis which considers goods as divisible or at least capable of repackaging, a visit to Hancock Tower is more readily modeled as a discrete choice. That is, the utility maximizing individual purchases entrance to the Tower if the marginal quality weighted gains meets or exceeds the marginal cost or entrance price. The maximum an individual would pay, a reservation price p*, can be modeled analytically and is, for the individual a function of view quality (q), income[1] (y), other goods prices $(\overline{p})$, and visit cost shifters such as inclement weather conditions. That is,

$$p_i^* = p_i(q, y, \bar{p}, w).$$

In this reservation price context the individual chooses to visit the site if p* meets or exceeds the price of admission, p^0. Hence, the individual demand for admission to the site is a zero-one valued choice index π_i,

$$\pi_i = \pi_i(p^o, q, y, \bar{p}, w).$$

Furthermore, we hypothesize that reservation price rises with an increase in quality. For the individual whose initial $p_i^*(q^o, y, \bar{p}, w)$ exceeds the market price, Figure 2 illustrates the gain in consumers' surplus (CS) due the quality change to q^1. Clearly, an individual who does not visit either before or after the quality change gains no consumer surplus due to the view quality change at the site.

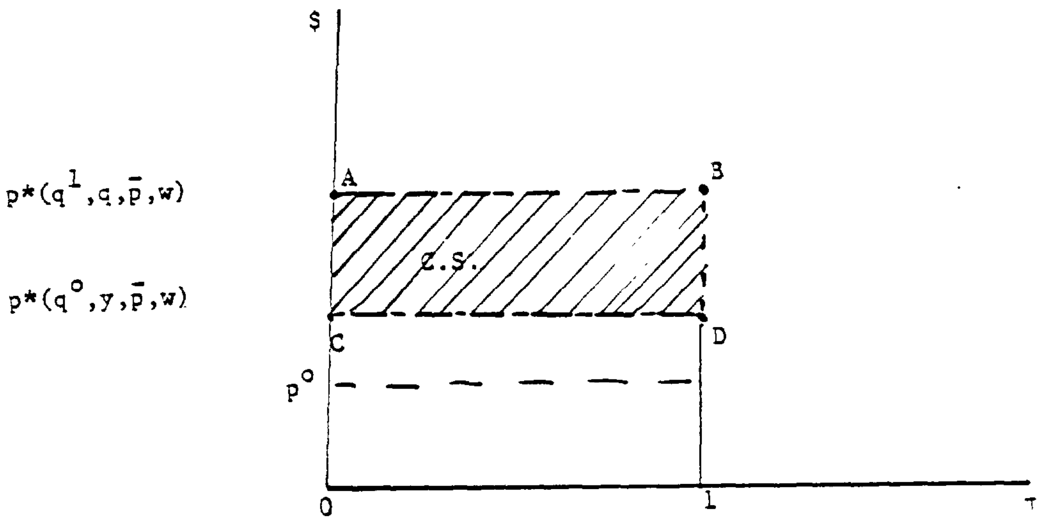


Figure 2

[1] When income is included, we are discussing the Marshallian demands. However, It can be shown that as the budget snare of a commodity approaches zero, as is likely in the present case, the Marshallian demands approximate the compensated demands.

Aggregate demand for access to the view at Hancock Tower is simple sum of individual demands. Hencs aggregate demand is considered a function of current Tower price, (p), view quality (q), income levels, other goods price, and the same weather variables (w) that affect individual choice. For given values of these variables, aggregate demand yields an attendance count. A particularly convenient functional foot for approximating aggregate demand is a modified Cobb-Douglas,

$$VST_{.} = Ap^{\alpha 1}q^{\alpha 2}q^{\alpha 3}t^{\alpha 4}a$$

where VST is the recorded number of visits for a particular day, A is a yet to be specified function of shifters, y is aggregate income, t is a time trend variable, and a is a lognomial error term. As steps prior to estimation, admission price charged at the Tower is deflated by a montly cost of living index and monthly real personal income for the U.S. proxies individual variations in income[2]. Other goods prices are not included explicitly in the analysis.

The shifter, A is specified as an exponential function of weather and time related variables such as day of week and seasonal cycles:

$$\begin{aligned} A &= A(w,d,s) \\ &= \exp(w,d,s) \end{aligned}$$

where d are day or week dummy variables. The seasonal vector, s, may be specified as either zero-one dummy for south or as sine and cosine functions of period 365. In the current case with daily observations, the sine and cosine functions are better suited to fit the likely smooth day to day change of a seasonal cycle.

[2] Both the cost of living index (CPI) and personal income are referenced in"Economic Indicator, January, 1980" and economic Indicators. Nov., 1980" prepared by the U.S. council of Economic Advisers.

For an initial specification of view quality, we reference recent work by Malm, et al., that seeks to develop tentative conceptual and empirical linkage between physical measurements and perceived view quality. The findings of Malm, et al., suggest that the relationship between perceived view quality, q, and color contrast, C_r, is linear:

$$q = AC_r$$

where A is a function of shift variables such as cloud cover, snow in scene, and time of day. Due to the tentative nature of the Malm, et al., view quality/color contrast relationship, it is convenient to allow a more general form. The function is generalized only slightly:

$$q = AC_r^{\beta}$$

where the relationship is linear if $\beta = 1$.

Malm, et al., go on to note that

$$C_r = C_o \, e^{-rb_{ext}}$$

where C_o is the inherent color contrast of a viewed object, r is the observer's distance from that object, and b_{ext} is a monochromatic or wavelength weighted, spacially averaged estinction coefficient. Furthermore, the extinction coefficient is related to visibility, v , by

$$v = 3.912/b_{ext}$$

Hence, the initial relationship between color contrast and view quality can be transformed to one between quality, object distance, and visibility or visual range,

$$q = AC_o \exp(-\beta r(3.912)/v)$$

or in log form,

$$\ln g = \ln AC_o - \beta r(3.912/v)$$

For a given site such as Hancock Tower, it may he considered a weighted average of viewed object distances. Such a transformation for view quality is particularly convenient for in the log - log form of the VST equation, visibility enters as

$$\alpha_3 \ln g = \alpha_3 \ln AC_o - \alpha_3 \beta r(3.912/v)$$

where α_3 1nA becomes either a component of the intercept or is added to the effect of demand shifters such as snowfall and cloud cover.

Once final estimates of the VST equation are completed, consumers surplus due to view quality change or visibility change at the site can be easily calculated as long as $\alpha_1 + 1<0$, where α_1 is the exponent of own-price. Consumers surplus (C.S.) for a quality change from q^0 to q^1 is the change in area underneath the aggregate demand curve at q^0 minus the area underneath aggregate demand at q^1,

$$= \lim_{\bar{p} \to \infty} \int_{p_o}^{\bar{p}} A(w,d,s)\, p^{\alpha_1} q^{\alpha_2} q_0^{\alpha_3} t^{\alpha_4}\, dp$$

$$- \lim_{\bar{p} \to \infty} \int_{p_o}^{\bar{p}} A(w,d,s)\, p^{\alpha_1} y^{\alpha_2} q_1^{\alpha_3} t^{\alpha_4}\, dp$$

Once CS is calculated it may be accepted as an approximation to compensating variation or transformed to compensating variation by well documented methods.

Estimates of VST were obtained using a log-log transformation and ordinary squares. Suggestive results appear in Table 1. The dependent variable is the log of total duly attendance and includes all but one day from the period from January, 1979, through June, 1980. In considering these results, one may keep in mind that average daily attendance is approximately 950 persons and the average deflated adult price of admission is about $0.79 in 1967 dollars. View quality variables are specified in a manner consistent with the Malm, et al, results. IVISB1 and IVTSB2 are simply the first (VISB1) and second (VISB2) visibility readings (miles) at the Tower, inverted and multiplied by the constant 3.912. Average VISB1 is about 12 miles and average VISB2 is about 16 miles for the period considered.[3] Weather observations are for O'Hare International Airport and were obtained from the National Climatic Center. Independent variables other than IVISB1 and IVISB2 are:

RP	= Log of deflated Tower admission price,
PI	= Log of deflated personal income,
LT	= Log of time trend variable,
RA	= Proportion of weather observations per day recording rainfall,
SN	= Proportion of weather observations per day recording snowfall,
CL	= Proportion of sky covered in clouds,

[3] IVISIB1 = 3.912/VISIB1 and IVISB2 = 3.912/VISB2

HTCL	=	Height of lowest layer clouds in hundreds of feet,
WIN	=	Average day windspeed in knots,
TEMP	=	Average daily temperature in degree fahrenheit,
M, Tu, W, F, S, Su,	=	Day of week zero/one dummy variable and
SNX CSX	=	Sine and cosine transformations of period 365.

Examining the statistical results of Table 1, both the F value and R^2 are adequate. Estimated coefficients tend to have expected signs. The price coefficient is very significant, has the expected sign, and indicate the elasticity of visitation with respect to a price change. The income variable, RPI, has neither the expected sign nor is it statistically significant. Rainfall, snow, and cloud cover are each statistically significant, have expected signs, and are quite substantial in effect. For example, ceteris paribus, a full day of rain reduces visitation to about one third of what if otherwise would have been (exp(-1.035)=.35). Both of the visibility related view quality variables IVISB1 and IVISB2 are statistically very significant and each having the expected signs; that is, as visibility increases, extinction coefficients (IVISB1 and IVISB2) decline. As the extinction coefficient declines, view quality increases and visitation rises. Hence, the coefficients or IVISB1 and IVISB2 are negative. Coefficients on day of week variables indicate that visitation an Friday and weekends differs significantly from visitation on weekdays. Seasonal variables indicate a strong seasonal cycle with a peak in mid-summer and a trough in early January.

A.11 VISIBILITY, VIEWS AND THE HOUSING MARKET

Freeman (1979a) identifies three major approaches which can be used to estimate the demand for a public good such as visibility. These approaches are: (1) analyze market transactions for something related to the public good to estimate the implicit demand for the public good itself, (2) collect individuals' stated values revealed through a contingent market for the public good and (3) analyze jurisdictional provision of public goods, taxes and constituency characteristics. Some important contributions on the aesthetic value of cleaner air have been made using the second approach, contingent valuation, with Rowe et. al. (1980), Schulze et. al. (1980) and Tolley et. al. (1980), focusing specifically on visibility. As Rowe et. al. and Freeman argue, the demand estimates based on contingent values are useful, but they are hardly definitive because of at least some concern about strategic and induced biases. While Brookshire et. al. (1979) maintain that these potential biases are practically negligible and that contingent valuation is reliable, some doubts remain. There is no question that our understanding can be improved by exploring other approaches.

The purpose of this section is to consider the prospects of using the implicit market approach to estimate the value of improved visibility through analysis of the housing market. This section is organized in the following way. The next part provides the theoretical basis for estimating the demands for housing amenities through the analysis of implicit markets for amenities. Part III reviews the relevant housing studies of the demand for amenities related to visibility. The concluding part deals with what further insights can be expected from studies of the housing market and suggests a way of obtaining that additional information on the value of improved visibility.

II. The Implicit Market for Housing Characteristics

Even casual observation suggests that housing is heterogeneous commodity composed of various important features other than structural characteristics alone. These non-structural housing characteristics are sometimes categorized as: (1) publically-provided services which include schools, fire protection and garbage collection and (2) neighborhood amenities which include such characteristics as accessibility, serenity and air quality. The substantial contribution of neighborhood amenities to the total price of a house has been established by numerous studies including that by Krumm (1980). Tolley and Diamond (1982) is devoted entirely to the role played by amenities in residence site choice. Currently estimation of the demand for housing amenities related to air quality follows some variant of the implicit market approach suggested by Rosen (1974).

Housing is viewed as a bundle of traits consisting of not only structural characteristics but neighborhood characteristics and services as well. Households respond to the traits themselves and, if they cannot rearrange or repackage them to exactly suit their tastes, the configuration of traits as well. Households choose a bundle of housing located at a particular site having only incidental dealings in the market for land. Utility is maximized over housing and other goods subject to an income constraint. and an exogenous, through not necessarily linear, price function for housing. As described by Blomquist and Worley (1981), such a process yields demand equations for each of the housing traits where own-price, the prices of complementary and substitutable traits, income, and tastes are determinants of trait demand. Given that the housing hedonic function (the market price of housing as a function of the quantities of the various housing characteristics) is interestingly non-linear, the demand for any particular characteristic is not directly obtainable in that the housing hedonic equation is a market clearing function influenced by supply as well as demand conditions. See Freeman (1979b). In order to get trait demand, we must estimate the market clearing function, calculate the marginal trait (hedonic) prices, and use these prices along with income, other demand shifters, and whatever is necessary to identify trait demand, see Witt *et*. *al*. (1979). By finding the area under the estimated demand curve, we can estimate the benefits of amenity provision. This housing market approach, while not without the limitations noted by Freeman (1979b) and Smith and Diamond (1980), provides useful information on the value of improved amenities. These estimates can be compared to that obtained by contingent valuation.

III. Housing Studies of Amenities Related to Visibility

A great deal of effort is being devoted to measuring the demands for clean air and pleasing views -- two housing amenities related to visibility.

Clean Air -- Recent representative studies of the demand for clean air are those by Harrison and Rubinfeld (1978) who use Boston census tract housing and household data to measure the benefits of reduced concentrations of nitrogen oxide and particulate, Nelson (1978) who uses Washington DC census tract and household data to measure the benefits of reduced concentrations of particulate and oxidants, Brookshire et. al. (1979) who use household-specific Los Angeles area data to measure the benefits of reduced concentrations of nitrogen oxides and particulates, and Bender et. al. (1980) who use household-specific Chicago data to measure the benefits of reduced concentrations of particulate. Table 1 shows the benefits per household of improved air quality as estimated by Harrison and Rubinfeld, Brookshire et. al. and Bender et. al. Given that these measurements are accurate, the estimated benefits of cleaner air are an upper bound on the value of improved neighborhood visibility to the resident households. Benefits of improved visibility outside the neighborhoods and benefits of improved neighborhood visibility to non-residents are not captured.

Shoreline -- Further information on the upper bound on the value of improved visibility comes from the study of pleasant views. Brown and Pollakowski (1977) use the housing market approach to estimate the value of shoreline. The value of shoreline property would reflect the desirability of quick access to water-related activities and also the desirability of views associated with water-related open space. Using house-specific data for sale price and housing characteristics, they estimate the value of shoreline in Seattle, Washington. They find that a house located in an area near a 200 foot-wide setback area will sell for about $2100 more than a comparable dwelling near a 100 foot-wide setback and that a house near a 300 foot-wide setback will sell for about $3336 more than a 700 foot-wide setback (again using the CPI to convert to June 1980 dollars). This estimated value of shoreline is

TABLE 1

The Benefits of Cleaner Air

Study	Area	Dependent Variable	Pollutants	Average Annual Benefits per Household[a]
Harrison & Rubinfeld	Boston	Median property values from census tract data	Nitrogen Oxides and Particulate	$187 for reductions from auto emission controls (90% reduction in tail-pipe emissions)
Brookshire *et. al*.	Los Angeles	Sale prices of individual houses	Nitrogen Oxides and Particulate	$686 for combined reduction of about 30% in average ambient levels
Bender *et. al*.	Chicago	Sale prices of individual houses	Particulate	$593 for a uniform 20% reduction.

[a]Benefits are converted to June 1980 dollars using the Consumer Price Index (CPI). The estimates shown are the best point estimates, but each study should be consulted for ranges and qualifications.

[b]A 10% discount rate is used to convert the estimate to an annual value.

Source: Calculated from Harrison and Rubinfeld (1978, p. 92), Brookshire *et. al*. (1979, p. 131) and Bender *et. al*. (1980, Table IV).

relevant, but of limited usefulness for two reasons. The first is that the value of visibility and viewing cannot be separated from that of access to water and park-related activity. The second is that the methodology fails to estimate the demand for shoreline unless we make the heroic assumption that the housing hedonic equation reveals the demand directly. Harrison and Rubinfled (1978), Bender et. al. (1980) and Blomquist and Worley (1981) all find, with different data sets, that there can be great differences between any benefits estimated directly from the hedonic and those estimated more appropriately using a two-step procedure.

Pleasing Views -- Abelson (1979) provides more specific information on the value of visibility-related amenities. In his analysis of housing prices in the Rockdale section of Sydney, Australia, he considers two environmental amenities of interest: (1) view, which is measured subjectively as good, average or poor and (2) block level, which indicates whether or not the house is either on the top side of sloping street or built well above street level. Abelson relates that some houses have views overlooking the Pacific Ocean and that views vary greatly in quality. For all houses in the sample, the value of a good view over an average view is 1.7% of the average house price, and the value of a good view over a poor view is 3.5% of the average house price. The value of a house built on a high block level is 5.5% of the average house price. If Abelson's specification is correct, then a house with a good view built on a high level is worth more than a house with a poor view built on a non-high level by 9% (or 2160 Australian dollars in 1972-73). This substantial percentage of the total house price suggests that view-related amenities are important and that even though the value of visibility is less than that of the view, it may still be non-negligible. Another of

Abelson's findings indicates that the values of view and visibility increase with income. For the sample with only houses priced above the average, he finds the values of good views over average views, good views over poor views and a house built on a high block level all to be approximately twice those for the entire sample. Thus, visibility-related amenities make up approximately 17% of the total value for higher-priced houses. This finding is substantiated by the positive simple correlations between good view and social status (.271) and between good view and external house condition (.156). As with the benefits of shoreline, these for viewing are estimated directly from the housing hedonic equation which reflects supply as well as demand conditions and consequently are subject to unknown bias.

The most exhaustive analysis of view-oriented residences is by Pollard (1977) who explores the implications of topographical amenities in an urban housing model. According to Pollard, visual amenities are a function of the breath (scope) of view which he measures by building height (floors) and the composition of the view. Since the data are composed of 232 Chicago apartments north of the Loop along Lake Michigan, dummy variables are created for each loopview and lakeview. Estimating a rental expenditure function and a building height function which he derives from a modified Muthian model, Pollard finds that the view affects both rents and building height. As shown in Table 2, the value of the views is approximately 14%-17% of average rental payments with values for lakeview and breadth of veiw based on significant regression coefficients and loopview on an insignificant coefficient. Given Pollard's estimate of total monthly rent in the study area is correct, the additional total rental premium paid for visual amenities is approximately $113 million in

TABLE 2

The Value of Loop and Lake Views in Chicago

A. VALUE OF VISUAL AMENITIES

Visual Amenity	Value of Amenity	
	Share of Average Rent	June 1980 Dollars per Year[a]
Lakeview	7%	$332
Loopview[b]	3%	$142
Breadth[c]	7%	$332
Total	14%-17%	$664-806

B. EXAMPLE OF A LOOP APARTMENT

Description of Apartment	Premium for Visual Amenity	
	Share of Rent of Apartment with View	June 1980 Dollars per Year
1st floor, no special view	---	---
10th floor, no special view	14%	$791
10th floor, Loopview[b]	17%	$957
10th floor, Lakeview	20%	$1177
10th floor, Loopview and Lakeview	22%	51343

[a]Values for 1975 are converted to June 1980 dollars using the CPI.

[b]The coefficient on which this estimate is based has a t-value of only 0.8.

[c]Since proximity to Lake Michigan increases building heights and hence the breadth of view, part of the value of breadth is due to a lakeview. Pollard finds that lakeview apartment buildings are 76% taller than non-lakeview buildings. The value of lakeview implied by taller buildings is 4.3% of average rent (.067 x 64 = 4.3 where 64 = 1.77 x 36). The value of breadth without the lake height effect is 2.4% of average height (.067 x 36 = 2.4).

Source: Pollard (1977).

1980 dollars (43.8 x 12 x .14 x 1.533 = 112.8 where 247.1/161.2 = 1.533). While we must again remember that these values come directly from the hedonic equation and not from the demands for visual amenities, Pollard's research clearly indicates their substantial impact on view-oriented residences and that dimensions of viewing can be successfully considered.

IV. Further Work Based on View-Oriented Residences

Conceptually, the value of any perceived housing characteristic (including area visibility) can be found through analysis of the implicit market for the characteristic. As described above, several studies have estimated the demand for clean air. However, no such study has been done for visibility, and given the extreme data requirements, it is quite unlikely that one will ever be done especially for a housing market as large as a Standard Metropolitan Statistical Area. In marked contrast is the excellent prospect for learning more about the value of views and components of views. We have seen that in view-oriented submarkets, there is some indication that viewing can be worth as much as 20% of total housing expenditures -- an effect readily detectable by statistical hedonic price-trait demand analysis with average quality data. We now address what such a study might entail.

Let us assume that households maximize their utility which is separable and depends on housing and a composite good excluding housing. Housing, which is a vector of housing characteristics, can be considered as having view-related characteristics such as breadth and composition as well as characteristics unrelated to viewing. Following the theory and methodology described in part II, we would estimate the hedonic housing function which includes the view-related characteristics estimate the

the demands for these special characteristics, and aggregate to get the value of views.

For a submarket like Pollard's where view-oriented residences are prominent, the hedonic housing function would specify rent as a function of structural characteristics such as floor space, rooms, baths, age, fireplaces, central air conditioning, central heating, units in building, floors in building, garage, separate storage area, building elevator; payment characteristics such as whether or not rent includes utilities, heating, air conditioning, garbage collection, parking; neighborhood characteristics such as access to employment and shopping, school quality, crime rate, street conditions, litter, noise, abandoned buildings; and view characteristics such as height of the apartment in floors, percentage of horizon which can be viewed from the apartment, a dummy for Lakeview, a dummy for Loopview, a dummy for ability to view to the horizon, and a dummy for extraordinary window space. (The hedonic equation can accommodate condominiums with adjustments for property taxes, and the annual flow of housing services similar to those found in Linneman (1980)). The best functional form for the hedonic function can be determined by using a quadratic Box-Cox procedure similar to that used by Bender et. al. (1980).

Estimating the demand for view characteristics will make use of the hedonic prices for housing characteristics and household characteristics such as income, family size, age structure and education. The proper specification of the demand equation can be determined through a series of tests for the superiority of alternatives following Blomquist and Worley (1982) and Harrison and Rubinfield (1978).

By coordinating the housing market and contingent valuation approaches to estimating the value of improved visibility progress can be made in critical areas of benefit estimation. First, sturctural and neighborhood housing characteristics obtained from cooperative building managers can be supplemented and matched with view and household characteristics obtained through the contingent valuation survey. This merger would permit estimating benefits from the demands for view characteristics, not the hedonic housing equation. Second, by carrying out a contingent valuation study for views (in addition to a study for visibility) we can compare the estimates of the value of views obtained from the housing (implicit) market and contingent market studies. Such a comparison is crucial to understanding the usefulness of contingent values of environmental amenities such as visibility which are not easily estimated by alternative approaches.